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CRUSHING AND GRINDING BIBLIOGRAPHY

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Mineral Processing Laboratory

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CANMET QUARTERLY BIBLIOGRAPHY OF CRUSHING AND GRINDING- MAY/JUNE 1980

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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	92:14-22; 1980
METADEX (Metal Abstracts)	80:3-6; 1980
NTIS (National Technical Information Service of the U.S. Dept of Commerce)	80:10-14; 1980
SCIENCE CITATION INDEX	80:14-21; 1980
COMPENDEX	80:5; 1980

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	13:5-6; 1980
IMM ABSTRACTS	June 1980

References are numbered sequentially and are grouped according to the main topics shown below. Not all topics need to be presented in any one report.

A) Review articles
B) Crushing
C) Rod and ball mill grinding
D) Autogenous, semi-autogenous and pebble grinding
E) Liners and wear
F) Grinding media
G) Classification
H) Modelling, kinetics and process control
I) Fracture
J) Applications
K) Novel methods

The author gratefully acknowledges the cooperation of R.J.C. MacDonald, L.L. Sirois and A.I. Stemerowicz, Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

CRUSHING

1321. Anon. "Control of air emissions from process operations in the rock crushing industry"; U.S.N.T.I.S. PB Rep 80-131840:97 pp.; 16 ref; Feb., 1979.

Three basic methods of controlling emissions from process operations in crushed stone plants are described - dry captive systems using fabric filters, wet suppression systems and combinations of these. Operational problems with these systems associated with plant portability and product size are discussed. Examples of good design practices and maintenance procedures for these control operations are covered. An electrostatic charged fog technique for control of small dust particles is described and operational problems listed. A second part analyzes the downwind effect of reducing emissions for worker safety. (Author)

1322. Flavel, Malcolm D. "Improved crushing plant performance shows the way to reducing iron ore processing costs"; Proc 52nd Annu Meet Minn Sect AIME; Jan. 10-12, 1979; Duluth, Minnesota; 13 pp.; May, 1980.

An increasingly important consideration in plant comminution is that of energy consumption. Generally as material proceeds through the process, the energy consumption required per unit of material increases. Thus the fine crushing stages and the grind mills require the most energy input. Milling machines are compared for their efficiencies, power rates, and physical limitations.

1323. Anon. "Foskor orders R3.5M crusher"; Coal Gold Base Miner South Afr 28:1:17-18; 1980.

1324. Anon. "Mobile installations for manufacture of road aggregates"; Equip Mec Carr Mater 181:25-26; (French); 1980.

In order to supply the materials necessary for reinforcement jobs coordinated by the R.N.6. between Pont Royal and Modane, Debernardi has installed two mobile operations for the preparation of aggregates which are intended to treat, on the one hand quarry rocks, and on the other hand, alluvial deposits. The operation is situated at Saint-Alban-d'Hurtières (Savoie) on the edge of the alluvial deposit site.

1325. Anon. "Crusher terminology. Crusher and Portable Plant Association" iv:39 pp.; Darien, Conn.; 1978.

Technical terms used with respect to crushers and crushing equipment are defined.

1326. Levine, S. "Underground crushers feed surface plant"; Pit Quarry 72:7:60-63; 1980.

1327. Hunt, G.R. and Royston, V.J.C. "Improvements in and relating to gyratory cone crushers"; British Patent 1, 570, 015; 1980.

1328. Anon. "Improvements in centrifugal impact rock crushers"; British Patent 1, 568, 922; 1980.

ROD AND BALL MILL GRINDING

1329. Nudel, M.E. and Krykhtin, G.S. "Calculation of grinding bodies in tube mills"; Tsement 2:14-15; (Russian); 1980.

1330. Onuma, E. "On the optimum ball filling ratio in closed-circuit ball-mills"; Micromeritics 24:13-16; (Japanese); 1979.

1331. Schonert, Klaus "Comminution of materials"; British Patent 1, 569, 521; 1980.

1332. Anon. "Grinding and drying equipment"; British Patent 1, 568, 785; 1980.

AUTOGENOUS, SEMI-AUTOGENOUS, AND PEBBLE GRINDING

1333. Rahter, J.M. "Recent design changes in pebble mills"; Proc Ceram Eng Sci-Materials & Equipment and Whitewares Division. Am Ceram Soc 1:9-10:871-2; 1980.

Changes in design and construction of pebble mills resulting in a reduction of required maintenance, noise, and wear of liners and grinding media are discussed. Problems with presently used gear-driven mills and brakes are also discussed with possible solutions presented.

1334. Heminsley, Herbert "Improvements in or relating to the comminution of solid materials"; British Patent 1, 569, 969; 1980.

1335. Hedlund, Maths "Rubber lining in primary grinding mills"; Proc 52nd Annu Meet Minn Sect AIME; Jan. 10-12, 1979; Duluth; 14 pp.; May, 1980.

Rubber is being explored as an alternative to steel in wear protection. This paper discusses design considerations for rubber linings and the reasons why steel wear protection design is not applicable to that for rubber. The design criteria are applied to rod, ball, and autogenous mills. Advantages of rubber linings over steel include: lower downtime, greater production, reduced maintenance costs, reduced weight, shorter installation time, flexible grates, less risk of accidents, and less noise.

1336. Shafeev, R.Sh.; Shoniya, Yu.D.; and Sturua, R.I. "Decrease of ball wear during grinding by slowing down their surface oxidation"; Sakartvelos Politeknikuri Instituti Shromebi Tr Gruz Politekhn IN-T 6:207:86-9; (Russian); 1978.

1337. Shoniya, Yu.V. and Shafeev, R.Sh. "Corrosive wear of balls during the wet fine grinding of ores"; Obogashch. Rud. Irkutsk 167-73; (Russian); 1979.

1338. Balashov, G.V.; Tyurin, N.G.; and Shcherbakov, O.K. "Decreasing the corrosion-erosion wear of steel balls, bars, and linings in ball mill grinding of ores"; Tsvetn Met 11:95-97; (Russian); Nov., 1978.

A 1.5L porcelain grinding mill with porcelain and steel balls of diameter 20-22 mm. is used for the grinding of quartz, pyrite, and Cu-Zn ore. Corrosion inhibitors including sodium nitrite, potassium chromate, calcined soda, limestone, and sodium hydroxide are also used in this analysis of corrosion-erosion. The corrosion rate is determined by the consumption of oxygen and the change in weight of the balls after grinding.

1339. Labecki, Mariusz "Selection of materials for grinding mill balls"; Zesz Nauk Politech Slask Mech 65:185-98; (Polish); 1978.

The tests covered four grades of chromium cast iron and included determination of hardness, crushing strength and wear resistance as well as metallographic examinations of as-cast and variously heat-treated balls. The optimum results were checked in industrial scale tests. (Author)

GRINDING MEDIA

1340. Zelenov, I.B. and Popov, L.N. "Additive for improving cement grinding"; U.S.S.R. patent 697, 433; Assignees: All-Union Correspondence Polytechnic Institue; (Russian); Nov. 15, 1979.

A 1.5-2 wt% aqueous solution of sodium salicylate - HCHO polymer was added to an 8 - 12.5 wt% naptha soap aqueous additive, resulting in increased output for cement grinders.

CLASSIFICATION

1341. Giles, W.B. and Bekofske, K.L. "Laminar flow cyclone development program. Quarterly technical progress report, October 1 - December 31, 1978"; U.S. Dept. Energy Rep FE-3242-2; 9 pp.; Jan., 1979.

In the cyclone separation process, it is undesirable to have turbulent mixing. The transition region between laminar and turbulent flows occurs at a low Reynolds number and hence a low velocity. Laminar flow with higher velocities can occur by suppressing the inlet turbulence and preventing boundary layer tripping. This paper analyzes the boundary layer and the factors which affect it, including a possible solution. (Authors)

1342. Forssberg, E. and Sandstrom, E. "Utilization of the Reichert cone concentrator in ore processing"; Ind Miner (St Etienne, Fr) Mineralurgie 4:223-231; 14 ref; Nov., 1979.

The problems with gravity concentration techniques are discussed. A possible solution to these problems is the Reichert cone concentrator which operates on the principle of fluidized bed separation on an inclined plane. Principles, construction specifications, and various applications in ore processing are also discussed.

1343. Lopatin, A.G. "Gravitation beneficiation of finely ground materials in short-cone hydrocyclones"; Kombinir Metody Pererab Medno-Nikelev Rud M 43-50; (Russian); 1979.

1344. Anon. "Small screen does big job in Virginia quarry"; Pit Quarry 72:9:54-57, 126; 1980.

1345. Haver, E.F. "Test Sieving with matched sieves"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 238-245; (German); 1979.

1346. Herrmann, H. and Leschonski,K. "Influence and correction of errors of particle-size-analysis in the determination of grade efficiency curves"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 41-58; (German); 1979.

1347. Heidenreich, E. "Combination of test sieving with the particle-analyser"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 218-237; (German); 1979.

1348. Scarlett, B. "The mathematical description of particle-size and shape"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 545-564; 1979.

This paper discusses three basic methods of expressing the size and shape of a particle. The classic method is to express the shape as an equivalent spherical diameter. Shape factors are then derived by comparing two independent measurements of size.

The second technique is to take statistical measurements of a particles dimensions, measurements which contain information about both the size and shape. Examples of such techniques are chord distributions, polar diagrams, and fractals. The basic similarity of all these approaches is discussed as well as the natural limitation to their uses.

This paper finally advocates a general approach to particle size and shape in which the parameters necessary to express the dimensions of a particle for solution of a particular problem may be vector or tensor quantities. (Author)

1349. Sommer, K. "Sampling for particle-size analysis"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 246-265; (German); 1979.

1350. Stanley-Wood, N.G. and Llewellyn, G.J. "On-stream particle-size and concentration measurements by auto-correlation of scattered laser light"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 197-217; 1979.

1351. Tuszko, W. and Janik, E. "Screen for granular materials"; British Patent 1, 568, 793; 1980.

1352. Pike, D.C. "Variability in grading results caused by standard sample-reduction techniques"; Transp Road Res Lab (England) PB 80-137474: 20 pp.; 5 ref; 1979.

In Great Britain, and elsewhere, the test that is carried out most frequently on aggregates is sieve analysis. Grading tests are quick and cheap, and provide information that can be useful to both producers and users of aggregates. Although they are frequently ignored, sampling and testing errors can contribute markedly to the variability of grading results. In this study eight sub-base materials (maximum size 37.5 mm) and two concrete aggregates (a 20 to 5 mm gravel and a sand) were subjected to the standard sample-reduction procedures, except that all sub-fractions were tested. It was found that a range of about 6% in grading at the 5 mm size could be induced by riffling the sub-bases to the appropriate size for testing. A similar result was found at the 10 mm size for the 20 to 5 mm gravel, and a range of 4 per cent was found at the 600 micron size for the concreting sand. These and other variables attributable to sampling, need to be taken into account when specifications are being drafted. (Author)

1353. Lyadov, V.V. and Mosin, M.K. "Classification of flotation tailings in hydrocyclones"; Coke Chem (USSR) 12:16-18; 2 ref; 1978.

This article analyzes a technological flowscheme providing for classification of flotation tailings on the basis of size in low-head hydrocyclones, followed by washing of the thickened product on a stationary screen. It is shown that it is cost-effective to add material with an ash content of 40% or less to the cleaned blend. (Authors)

1354. Scheffler, P. and Zahr, P. "Wet classification at cut points below 10 microns"; World Min 33:3:50-3; 1980.

Hydrocyclones are capable of classifying superfine solids to about 10 microns at which point a solid-bowl centrifuge becomes more advantageous. The solid-bowl centrifuge is especially useful for exact classification of a mineral and for separation of valuable minerals from otherwise discarded tailings.

MODELLING KINETICS AND PROCESS CONTROL

1355. Ramirez-Castro, J. and Finch, J.A. "Simulation of a grinding circuit change to reduce lead sliming"; Can Min Metall Bull 73:816:132-139; 1980.

Galena is the finest component of the product of a closed-circuit grind treating a lead-zinc ore, largely due to preferential recycling of this high-density mineral by the cyclone. For example, at the Pine Point Mines concentrator, for 55%-200 mesh over-all, the galena will be close to 95%-200 mesh. This sliming of the lead can limit recovery, selectivity and dewatering. A proposed circuit modification to reduce the sliming is to incorporate a unit cell. A simulator was constructed to study the No. 3 grinding circuit at Pine Point modified by a unit cell on ball mill discharge (BMD).

The simulator used a cumulative size basis rate-of-breakage with plug flow ball mill model, the parameters being obtained by laboratory grinding tests. Flotation and the cyclone models used a cumulative recovery/size matrix. The behaviour of each mineral, galena, sphalerite, pyrite and calcite/dolomite, was simulated. Simulation was adapted to a programmable calculator. A close fit to the existing circuit performance at two tonnages and mineral mixes was established.

The simulator showed that the modified circuit could significantly coarsen the Pb grind, from 95% to ~ 50%-200 mesh, depending on recovery, without substantially altering the size of the other minerals. The other principal findings were: compared to laboratory flotation tests on existing circuit BMD, the unit cell concentrate (CONC) will be coarser and markedly lower in grade; relatively low unit cell stage recoveries are desirable, because the cyclone scavenges the tail to give a circuit recovery which is higher than the unit cell stage recovery; unit cell stage recovery

should not exceed the cyclone stage recovery, as the latter is the maximum circuit recovery; low unit cell stage recovery helps offset the disadvantage of the high flow at BMD; other high-density minerals will also be scavenged into the CONC, as illustrated by pyrite, making CONC quality difficult to maintain; density control of BMD flotation does not greatly alter feed density to the cyclone or ball mill.

Possible plant metallurgy is forecast for a CONC diverted to final lead concentrate. (Authors)

1356. Domanowski, A.; Derbsch, K. and Sommer, H.P. "Considerations on the controllability of grinding-classifying circuits in the cement industry"; Zem-Kalk Gips 33:4:188-189; (German); 1980.

Control methods applicable to grinding-classifying circuits are described. The optimum operating point is sought by the process computers themselves, with the aid of extreme value search algorithms. The article draws attention to a new possibility with a DDC control program. (Authors)

1357. Watanabe, Haruo "Mathematical models of fractional grade efficiency curve"; J Soc Powder Technol Jpn 17:3:140-147; (Japanese); 1980.

1358. Dorfler, Robert R. "Development of an automated process at the Climax mill"; Prepr SME-AIME Annu Meet no.79-31:10 pp.; Feb., 1979.

The development of the automated process by the Climax mill and the events which affected the timing and final control logic are discussed. Emphasis is particularily on the automation of the ball mill grinding, classification, and flotation process.

1359. Diadkin, V.I. and Ziskel, A.S. "Operating experience of automatic control systems for raw material grinding using the wet process of cement production"; Tsement 3:17 -18; (Russian); 1980.

1360. Pochebut, N.S. and Volichko, Y.L. "Operating experience of automatic control systems for raw material grinding using the dry process of cement production"; Tsement 3:15-17; (Russian); 1980.

1361. Herbst, J.A. and Fuerstenau, D.W. "Scale-up procedure for continuous grinding mill design using population balance models"; Int J Miner Process 7:1:1-31; 1980.

This paper presents the development of a mill scale-up procedure based on population balance models of grinding circuits. Models containing various degrees of details in their representation of the kinetics of breakage, material transport through the mill, and performance of the classifier are examined; and the extent to which each may be useful for design is discussed. Special attention is given to the type of experimental information required at the bench, pilot-plant and plant scales to enable these models to be applied successfully to the design of continuous grinding mills. The grinding subprocesses: breakage, transport, and classification are taken into account in developing the present scale-up/design procedure. Utilization of the concept of specific energy consumption in kinetic models is demonstrated. The mechanics of design of a commercial-scale mill within the population balance model framework presented in this paper are illustrated using batch data obtained for the dry ball milling of limestone. (Author)

1362. Asai, N.; Kosaka, S. and Jimbo, G. "Derivation of breakage function assuming Alyavdin-Chujyo equation to apply"; J Soc Powder Technol Jpn 17:3:136-139; (Japanese); 1980

Alyavdin-Chujyo equation in ball milling is experimentally recognized over the wide range of grinding time. It is the purpose of this paper to derive the selection and breakage function from the size distributions, on the assumption that Alyavdin-Chujyo equation is recognized. It was observed that the selection and the breakage function is the equation including the term of time. (Authors)

1363. Grbovic, M. And Vasic, V. "Automatic control of hydrocone crushers in the Majdenpek Copper Mine"; Rud. Glas. 4:38-43; (Slovenian); 1979.

In order to produce a finer crushing product in Majdanpek Crushing Plant, automatic control of crusher discharge opening was introduced in dependence with oil pressure magnitude in the hydroset and electric motor loading. The realized results indicate that a finer crushing product is obtained reflected by a reduced proportion of class +25 mm by 3 to 4 per cent. (Authors)

1364. Grosanu, I. and Dragulescu, D. "Study on the stationary state of a vibrating screen"; Lucr Stiint-Inst Invatamint Super Oradea Ser A. 23-7; (Romanian); 1977.

This paper contains the study of periodical steady-state of a vibrating sieve. It is thought that the sieve is actuated by an asynchronous electric motor by means of two crank and connecting rods.
In the assumption that the crank and connecting rods are negligible masses, there are possible five periodical steady state operation from which only three are stable. (Authors)

1365. Hoberg, H. and Schneider, F.U. "The analysis of the state of grinding using kinetic solution experiments"; Proc 2nd Eur Symp Particle Characterisation; edited by K. Leschonski and W. Hufnagel; Nurnberg; 78-90; (German); 1979.

APPLICATIONS

1366. Kalmar, Z. and Heinz, Minaly (ed.) "Crushed carbonate aggregates influencing the properties of concretes"; Colloq Int Mater Granulaires (C.R.) 1:205-15; 1978.

1367. Uehara, Yasuhiko; Asai, Nobuyoshi and Jimbo, Genji "Effect of gas atmosphere on ball mill grinding of graphite"; Kagaku Kogaku Ronbunshu 6:1:101-3; (Japanese); 1980.

The effect of gas atmosphere on the rate of ball mill grinding and the consequent structural change of graphite was examined by using a ball mill with two kinds of atmosphere, oxygen and helium. It was found that the rate of grinding in helium was about seventeen times greater than that in oxygen, and this phenomenon was explained by the difference of breakage mechanism of graphite, cleavage breaking in oxygen and noncleavage in helium. The structural change of graphite was expressed in terms of the indices of specific structural change based on the new surface produced, $\Delta B_{eff} / \Delta S_w$ and $\Delta \alpha_{Rh} / \Delta S_w$. These were found to be constant against grinding energy consumed irrespective of the type of ball mill, and were greatly affected by the kind of atmosphere, which was explained by the difference of frictional coefficient of graphite in each atmosphere. (Authors)

1368. Ebner, J.E. "Tumbling mill"; U.S. Patent 4,194,710; 1980.

1369. Utsugi, H. and Endo, A. "Grinding and surface treatment of quartz in cetyl alcohol in two kinds of ball mill"; J Soc Mater Sci Jpn 28:312:810-814; (Japanese); 1979.

Grinding of quartz was carried out in cetyl alcohol with two kinds of ball mill; the one was made of glass and the other was a rotating micro autoclave made of stainless steel. The results were compared with those of the ones without cetyl alcohol. The grinding conditions were from 2 hours to 64 hours at room temperature or high temperatures.

The effect of cetyl alcohol, temperature and grinding hour on the size distribution of quartz particles were investigated by sedimentation and scanning electron microscopy. It was found that the percentage under 15 microns diameter of the treated quartz was larger than that of the non-treated quartz and the degree of coagulation of the treated particles was less than that of the non-treated one. The effect of temperature was not clearly seen. (Authors)

1370. Bobkov, S.P.; Blinichev, V.N.; and Guyumdzhyan, P.P. "Effect of the type of mill on energy outlays and mechanochemical phenomena in fine grinding"; Izv Vyssh Uchebn Zaved Khim Khim Tekhnol 22:8:1004-7; (Russian); 1979.

The type of mill and hence the procedure for loading of material is studied for the effect on the power consumption and degree of activation of the material. Tests compare the power consumption for the ball, vibration, and impact mills for the grinding of several materials including limestone, gypsum, and cement clinker.

1371. Powlson, D.S. "The effects of grinding on microbial and non-microbial organic matter in soil"; J Soil Sci 31:1:77-85; 23 ref; 1980.

Grinding more than doubled the respiration rate of two silt loam soils, one arable and one grassland. The increases were smaller when the grinding treatment was given to portions of soils that had previously been fumigated with $CHCl_3$ and incubated, a treatment that greatly decreased microbial biomass.

The results indicate that the flush of decomposition caused by grinding was in part derived from killed organisms and in part from enhanced decomposition of non-biomass sections of the soil organic matter. Grinding killed about a quarter of the biomass in both soils. Carbon from killed organisms accounted for a quarter of the extra CO_2-C evolved after grinding in the arable soil and almost half in the grassland soil. The extra non-biomass organic matter decomposing after grinding amounted to about 0.5% of the soil organic carbon in both soils. This non-biomass material rendered decomposable by grinding had a higher C/N ratio than the organic matter decomposing in unground soil. (Author)

1372. Azovtsev, S.N. and Gaidukov, E.E. "Crushing of carbonate rocks by blasting on various scales"; Sov Min Sci 15:2:178-181; 1979.

The fragment size in rock blasts will be approximately the same for similar distances however, the fragment-size composition of the blasted rock is dependent upon fractures and inhomogeneity in the rock. The distribution density of blasted rock is investigated and the factors which affect it are analyzed.

1373. Spurny, K.R.; Stober, W.; Opeila, H.; and Weiss, G. "On the problem of milling and ultrasonic treatment of asbestos and glass-fibers in biological and analytical applications"; Am Ind Hyg Assoc J 41:3:198-203; 10 ref; 1980.

In preparing fiber suspensions for biological applications, as well as in many analytical procedures, the fibers-e.g. asbestos and glass-often have to be mechanically diminished and ultrasonically treated. Such treatments may sometimes produce changes in the physical and chemical properties of the original fiber samples. Measurements have been made to estimate the changes in fiber shape, size, and structure after milling and ultrasonic treatment.

The results have shown that milling procedures not only change the size distribution, but also the particle shape and crystal structure of asbestos fibers. Ultrasonic energy (50 kHz) had practically no influence on the crystal structure, but in long-term applications it produces changes in fiber size and fiber concentration. (Authors)

1374. Paul, S.K. "Underground crusher and conveyor system at Ruttan Mine, Sherritt-Gordon Mines Ltd."; Can Min Metall Bull 73:814:52-57; 1980.

This paper briefly describes the underground crushing and conveying system at Sherritt Gordon Mines' Ruttan Mine. A series of three steel-cord belted conveyors, with a total length of 2155 metres and a total vertical lift of 407 metres, convey the muck from the underground crushing station to the mill at the surface. The maximum size of the crushed rock is 6 in. All the conveyors are provided with numerous safety and fire suppression devices. (Author)

1375. Sentemova, V.A.; Kasenov, Sh.Z.; and Mamedov, T.A. "Ways of improving operating indexes of the concentrating mill of the Azerbaidzhan ore dressing plant"; Obogashch Rud (Leningrad) 24:3:5-9; (Russian); 1979.

1376. Filonenko,Y.F. and Seredkin, A.E. "Selecting the optimum degree of crushing of a coal charge"; Coke Chem USSR 4:18-20; 1978.

Results are given from studies to select the optimum degree of crushing of a coal charge for the conditions of the Novolipetsk I&SW. The studies proceeded from a predetermined relationship between coke quality indices and blast-furnace productivity. It was shown that blast-furnace productivity is correlated with coke strength. This parameter was chosen as the deciding factor in determining the optimum degree of crushing. (Authors)

1377. Dashkevich. R.Ya.; Bilenko, L.F.; and Kostin, I.M. "Study of characteristics of simultaneous grinding of raw material charge components from alumina production"; Obogashch Rud(Leningrad) 24:4:21-5; (Russian); 1979.

CANMET QUARTERLY BIBLIOGRAPHY OF CRUSHING AND GRINDING- JULY/AUGUST/SEPTEMBER 1980

D.G. Vandenhoff

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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	92:24-26; 1980 93:02-08; 1980
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NTIS (National Technical Information Service of the U.S. Dept of Commerce)	80:15-21; 1980
SCIENCE CITATION INDEX	80:22-35; 1980
COMPENDEX	80:6-9; 1980

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	13:7-9; 1980
IMM ABSTRACTS	August 1980

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The author gratefully acknowledges the cooperation of R.J.C. MacDonald, L.L. Sirois and A.I. Stemerowicz, Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

REVIEW ARTICLES

1378. Anon. "Crushing and Screening"; S Afr Min Eng J 91:4160:59-85; 1980.

A likely explosion in the rate of exploitation of South Africa's mineral wealth coupled with the development of new mining and blasting methods will put ever increasing demands on the throughput rates and size of individual chunks of material to be handled by crushing equipment.

As already reported in the journal, a significant development in open-cast mining has been the propagation of the concept of in-pit crushing, employing mobile or semi-mobile crushers in conjunction with shiftable conveyor systems. The object here being to cut the high cost of operating huge dump trucks consuming as much as 100 litres of diesel fuel an hour by reducing their haul cycles or replacing them completely with conveyors.

Iscor plans to use such a system for overburden removal at its Grootegeluk opencast coal mine and also a pilot installation of this type at Sishen iron ore mine. Another mobile crusher now being manufactured and scheduled for commissioning at the end of this year has been ordered by Foskor. This will be among the biggest in the world.

We look at all these interesting new developments and at one of the first mobile crusher installations, Anglo Alpha's Dudfield operation near Lichtenburg where a 450 ton unit has operated since 1977. The crushing and screening of coal is another important area covered and, as usual in such features we look at the latest equipment and techniques available from manufacturers in this field. (Author)

1379. Mollick, L. "Crushing"; Eng Min J 181:6:96-103; 4 ref; 1980.

The parameters involved in choosing a crusher are the feed and product sizes, the type of ore to be crushed, production requirements, and maintenance costs. This article concentrates primarily on the comparison between gyratory and jaw crushers. Open and closed circuits as well as automatic control of crushing operations are also discussed. Considerations to be made in the future are suggested.

1380. Anon. "Grinding"; Eng Min J 181:6:106-113; 5 ref; 1980.

The demand for increased grinding capacity, coupled with steadily declining ore grades and limited capital for plant expansion, have resulted in the design and construction of increasingly larger grinding mills. This increase in mill size, which has only in recent years levelled off, has often resulted in fewer grinding machines per plant with a greater dependence on each machine. The necessity for increased equipment reliability has compelled manufacturers of mills, drives, castings, and other components to implement a number of innovative designs and refinements. The current trend focuses on stepping up refinements with respect to mill control systems design. (Author)

1381. Petrik, Z. "Crushing and grinding"; Tech Zpr 17:5:1-4; (Czechoslovakian); 1977.

1382. Srestry, G.C. and Venkateswar, R. "Particle-size analysis - A review"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 1:329-365; 91 ref; 1980.

Size measurement is important in characterization of fine particles. Commonly employed size measurement techniques such as sieving, microscopy, and sedimentation are discussed in this paper. Operating principles, advantages and limitations of these techniques are discussed based on the published information and working knowledge with several of these instruments at the authors' laboratories. A brief description of the recently developed equipment for fine particle characterization is also included. At the end of the paper, a rationale is presented for selection of the size analysis equipment based on specific requirements. (Authors)

CRUSHING

1383. Robertson, Joseph L. "Three-in-one plant produces crushed stone, riprap, aglime"; Rock Prod 82:11:64-68; Nov., 1979.

1384. Gehrke, B. "New findings on coal crushers for large power plants"; Kraftwerke Vortr (VGB-Kongr) 250-8; (German); 1978.

This paper gives descriptions of various types of coal crushers.

1385. Smelyanskii, A.Z. and Stepanov, Y.V. "On the proper extent of selective crushing of a coal charge"; Coke Chem USSR 8:3-5; 6 ref; 1978.

Studies were performed to determine the proper degree of crushing of a coal charge when selective crushing is used. Various methods were used, including separation of the liquid phase from the plastic mass, dilatometer analysis, etc. (Authors)

1386. Sushina, N.I. and Ryabichenko, A.D. "Reduction of the degree of crushing of a charge for coking at the Western Siberia Iron and Steel Works"; Coke Chem USSR 9:15-20; 1 ref; 1978.

The proximate composition and properties of individual classes of concentrates from the Kuznetsk Central Washery and Western Siberia I & SW Washery are studied. The nature of distribution of the ash by classes is determined. It is shown that the proximate composition and caking capacity of charges prepared by differential crushing practically do not change on change of the degree of crushing from 77 to 91% content of the < 3 mm class, although there is a decrease in the content of fines in the charge and an increase in its bulk density. The coke retains its mechanical strength, and the abradability decreases. A system for differential crushing of the components is recommended and the optimum degree of crushing of the charge is determined. (Authors)

1387. Partridge, Philip "Crushers"; British Patent 1,572,591; 1980.

1388. Zanker, A. "How to size smooth roll crushers"; Min Eng (NY) 32:6:664-665; 1980.

The parameters considered when sizing smooth roll crushers are the diameter of the rolls, the clearance between the rolls, feed size, and the coefficient of internal friction of material to be crushed. Equations relating these parameters are given and a nomograph for graphical solution is also presented.

1389. Kiss, L. and Schonert, K. "Liberation of two component material by single particle compression and impact crushing"; Aufbereit Tech 21:5:223-230; 1980.

Single particle crushing experiments were done to investigate whether impact or compression crushing is more suitable for liberation crushing. 10-mm-spheres consisting of cement stone and embedded quartz particles were used as a mineral model material. Content and fineness of the quartz particles were varied as well as the loading conditions. The results are that the degree of liberation depends mainly on the degree of size reduction but the manner of loading has no or only a weak influence. (Authors)

1390. Peterson, R.I. "Comminution device"; U.S. Patent 4,200,243; 1980.

1391. Jimbo, Genji "Crushing apparatus"; Kemikaru Enjiniyaringu 24:1:82-5; (Japanese); 1979.

1392. Privicevic, Milos "Dynamic effects in cone crusher foundations--exemplified by the foundations constructed in flotation plant Stari Trg (Yugoslavia)"; Rud Glas 4:67-73; (Yugoslavian); 1979.

Modern principles of structure design and calculation require an appropriate treatment of all effects acting upon the structure. A common practice was, and still is, to complete a dynamic calculation proving the structure stability against dynamic effects too in the design of foundations of large machines causing dynamic effects. The paper outlines a calculation methodology applicable for all types of cone crushers. (Author)

1393. Lebedev, V.V.; Khrenkova, T.M. and Goldenko, N.L. "Formation of paramagnetic centers during crushing of coal"; Solid Fuel Chem 12:6:117-119; 16 ref; 1978.

The use of a combination of EPR and IR-spectroscopy in the study of crushed and vibratory milled samples of coking coal showed that paramagnetic centers are formed in the crushing process and that their concentration increases with increase of the milling time. These centers are free radicals, and they appear as a result of breakage of chemical bonds in the mechanical destruction process, with an unpaired electron on the primary and secondary carbon atom. (Authors)

1394. Yashima, Saburo; Morohashi, Shoichi and Saito, Fumio "Single particle crushing under slow rate of loading"; Sci Rep Res Inst Tohoku Univ Ser A 28:1:116-133; 9 ref; December, 1979.

An experimental study of the single particle crushing under a slow(constant) rate of loading was carried out using specimens shaped into sphere made of quartz glass, borosilicate glass and six kinds of minerals. The diameters of sphere ranged from 0.5 to 3.0 cm and the rate of loading was fixed at 3 ton/min for the quartz glass and borosilicate glass specimens and 0.3 ton/min for the six kinds of minerals, respectively. A summary of experimental results is as follows: 1) compressive strength of specimens was increased with the decrease of their volumes; 2) the status of fracture was mainly transcrystalline type; 3) in the case of hard material, experimental values of strain energy agreed fairly well with the theoretical values; 4) the strain energy was proportional to (1- 5/3m) power of volume specimen, where "m" is the Weibull's coefficient of uniformity; 5) in coarse size range, the energy rule of single particle crushing was followed approximately by Rittinger's law; 6) the reciprocal of size modulus of fractured products was proportional to (5/3) power of the compressive strength of specimen; 7) after obtaining the required energy where the crushing is made by a mill of industrial scale by applying the values of work index, the percentage of the strain energy at the time of fracture of a single spherical particle to the required energy was found 2.71 to 42.0 percent. (Authors)

1395. Anon. "New cone crusher with central hydraulic adjustment"; Can Min Metall Bull 73:819:95; 1980.

1396. Anon. "Crusher breakdowns eliminated by magnetic protection"; Can Min Metall Bull 73:819:95; 1980.

1397. Kopacz, J. "New technique for breaking oversized lumps using the Rammer S800 hydraulic hammer"; Cem Wapno Gips 1:19-22; (Polish); 1980.

Technical-operating data of hydraulic hammer Rammer S800 are given and cost per piece of oversize lumps breaking with this hammer is compared with the cost of breaking by traditional techniques. The virtues and shortcomings of both, Rammer S800 hammer and traditional techniques of breaking are shown. (Author)

ROD AND BALL MILL GRINDING

1398. Uhlmann, J. "Investigation of air-swept mills with different design features of the grinding compartment"; Zem Kalk Gips 33:5:226-231; (German); 1980.

The behaviour of an air-swept grinding mill is decisively influenced by the air rate and by the speed of the mill. In order to have acceptable pressure drop, maximum throughput of finished product and optimum specific power consumption, a speed ratio of 0.76 is desirable. The particle size distribution of the mill product and of the tailings, as also the recycle ratio, are independent of the internal design features of the grinding compartment. They are a function of the mill air flow rate and velocity. From the viewpoint of pressure drop a mill without intermediate diaphragm is advantageous. (Author)

1399. Hotsuta, Naoaki; Masuko, Shoichi and Sakuyama, Hirohiko "Preventing leakage of powdered coal from ball mills"; Jpn Patent 80 27006; 3pp.; (Japanese); February 26, 1980.

1400. Jimbo, Genji "Fine powder crushing technology and grinding apparatus"; Kemikaru Enjiniyaringu 24:8:717-22; (Japanese); 1979.

1401. Beke, B. "The future of ball mills and roller mills"; Cem Wapno Gips 1:10-15; 16 ref; (Polish); 1980.

Basic tendencies in cement industry development call in the domain of milling technique for compliance with following requirements:
- elaboration and construction of milling units having the power of 15 000 kW,
- obtainment of high indices of mill installations worktime,
- economical energy consumption.

These requirements in the case of cement milling can be fulfilled only by ball mills, whereas for raw materials grinding both ball mills and roller mills are useful. However in the case of ball mills the handling of the ball charge amounting to 1000 tons seems to raise insurmountable difficulties. Big production units allow substantial investment savings and the roller mills are characterized above all by very low energy consumption. Nevertheless, elaboration and initiation of production of special constructional elements with very high wear resistance is the first condition of this development. (Author)

1402. Płaczek, J. and Chycki, A. "Rod-mills versus ball-mills in milling systems" Pr Inst Met Niezel 8:2:60-65; (Polish); 1979.

AUTOGENOUS, SEMI-AUTOGENOUS AND PEBBLE GRINDING

1403. Okuda, S. and Choi, W.S. "Grinding characteristics of target type fluid-energy mill"; J Chem Eng Jpn 13:3:219-225; 12 ref; 1980.

This paper deals with the grinding characteristics of a target type fluid-energy mill, in which flying particles are ground by repeated impact on a target. The increase of specific surface area ΔS_w and the distribution of particle size were investigated with respect to the following parameters: the target distance from nozzle outlet to target surface L, the target angle between air flow axis and target surface, the mixing ratio m of particles to air by weight, and the initial air pressure.

It was found that there were optimum L and m values for grinding, estimated to be 70 ± 10 mm for L and 0.7-1.0 for m over almost all the experimental range. The energy efficiency $\Delta S_w/E_f$, defined as ΔS_w per energy E_f in adiabatic expansion of air, was proportional to 1.0-1.2 power of m to m = 0.7.

On the other hand, the input energy per unit products was inversely proportional to the particle size of products in the region of fine particle size, while it was independent of the particle size of products in the region of large particle size. (Authors)

1404. Gunne, H.P. "Principle of operation and performance of an air impact mill"; vt Verfahrenstechnik 14:5:326-329; (German); 1980.

1405. Sysolyatin, S.A. and Pershukov, A.A. "Prospects of using selective grinding in a gas-jet grinder"; Gorn Zh 4:53-4; (Russian); 1980.

The gas-jet grinder is compared with a rod mill in the selective comminution of chromium ore. The main advantage of the gas-jet mill is its ability to be used for dry-enrichment schemes.

1406. Digre, Marcus (ed.) "Proceedings of the autogenous grinding seminar, Trondheim, Norway, 28-30 May, 1979"; 2 vols; Trondheim, University of Trondheim; 1980.

Thirty-eight papers are presented with the main theme being wet autogenous or semi-autogenous grinding. Pebble grinding however, is also covered to some extent. The papers are divided into 7 categories including: fundamentals; mill and mill circuit design; operating experiences; economics; modelling, simulating, regulating; testing and scale-up; and mechanical problems with large mills.

1407. Themelis, N.J. and Last, A.W. "Semiautogenous grinding of copper ores"; Min Eng (NY) 32:6:692-697; 1980.

The development of semi-autogenous grinding mills for use in the grinding of copper ore, mechanisms of size reduction, process design factors, and pilot testing of projected semi-autogenous grinding circuits are discussed. Results indicate that the semi-autogenous grinding circuit offers capital and operating cost advantages over conventional milling.

1408. Pitchumani, B. and Venkateswarlu, D. "Studies in fluid energy grinding - Part 1"; Aufbereit Tech 21:5:238-244; (German); 1980.

About studies in fluid energy grinding is reported. The entire lower part of the mill is effective and can be utilised for fixing grinding nozzles. Location of injector nozzle at the solids feed point results in a better performance of the mill. Convergent-divergent nozzle gives finer product than through-holed nozzle. Material of finer size is obtained when a restrictor is incorporated in the product outlet of the mill. The significant variables are mill diameter, nozzle diameter, grinding nozzle pressure and feed rate. The effect of injector nozzle pressure and feed size are less significant. (Authors)

1409. Boloni, I. "Theory, technique and practical application of hammer mills"; Aufbereit Tech 21:5:245-252; (German); 1980.

During the past twenty years numerous tests have been carried out for clarifying the mode of operation of hammer mills. The paper reports in detail on recent experience that has resulted in the development of a new mill featuring closed-circuit operation.

The most important results are specified below: The size distribution of the bruised grain can be described mathematically either by a log-normal or by the Rossin-Rammler distribution function. There is a positive inter-relation between the average grain size of the bruised grain and the variation of average grain size. The flour portion of bruised grain when ground in a closed circuit is by 10% to 24.5% smaller than during continuous grinding in an open circuit. The interrelations existing between the bruised-grain quantity governing the mode of operation of the mill, the increase in the specific surface of the bruised grain, the enlargement of the surface and the power requirement can be shown graphically in a four-quarter nomogram. Based on the mathematical model and by applying the Rittinger theory, these inter-relations can be expressed as simple equations with the aid of three and four parameters respectively. The energy required for reduction so as to produce 1 cm^2 of new surface is by 14.4% to 17% lower for closed-circuit than for open-circuit grinding. The reduction process is basically governed by the bruised-grain capacity but only indirectly by the filling charge of the mill. (Author)

1410. Skelton, R.; Khayyat, A.N. and Temple, R.G. "Fluid energy milling - an investigation of micronizer performance"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas; 1:113-125; 9 ref; 1980

The fluid energy mill has been in use since the 1930's when an early patent was granted to N.H. Andrews in the U.S.A. The microniser design has been basically unaltered since that date and current designs such as the Airfilco "Micronizer" have been progressively developed from results based on wide experience. The authors have been engaged in a research programme to establish optimum design and operational parameters for the Micronizer so as to provide a more quantitative

basis for scale-up prediction of results.

An introductory section will first trace the development of fluid energy milling including reference to other designs which have developed alongside the micronizer (especially the "Jet-o-miser").

With regard to design features the number of fluid injection nozzles and their size was investigated to establish the optimum range. Injection angle and the consequent diameter of the internal "tangential circle" was carefully studied to determine the effect of this parameter on product size.

The research was carried out using fine limestone as the test material with air as the grinding medium. Feed size fraction of 0-120 microns, 0-250 microns, 0-500 microns, and 300-600 microns were milled and product size analyses were carried out using the Coulter Counter technique. (Authors)

1411. Davis, E.G.; Hansen, J.P. and Sullivan, F.V. "Attrition microgrinding"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 1:74-95; 15 ref; 1980.

As part of its overall goal to maintain an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines, U.S. Department of the Interior, investigated the feasibility of producing subsieve-size material by an attrition grinding method. The Bureau-patented technique employed intense agitation of a mixture of the material to be ground, a granular grinding media, and a suspending fluid. A variety of materials were successfully ground to extremely fine particle sizes. Studies were made to determine the method's efficiency in grinding industrial minerals and metals to minus 2 micrometers and ceramic powders to an average particle size of 500 angstroms. Transfer of this technology to a commercial scale has been achieved. Commercial-scale units are currently being used in the paper-coating clay and titania pigment industries. (Authors)

1412. Anon. "Boliden: Two-stage autogenous grinding and process control expertise available"; Can Min J 101:6:S9-12; 1980.

1413. Anon. "Quick change panels for trommels on Hibtac grinding mills"; Eng Min J 181:6:175; 1980.

1414. Weymont, N.P. "The analysis and simulation of autogenous grinding systems"; Ph.D. thesis, Pennsylvania State University; UM Order No. 8010109: 440 pp.; 1979.

LINERS AND WEAR

1415. Douglas, L.S. and Ditchburn, R.G. "Radiometric assessment of abrasiveness of coal in pulverizers"; Fuel 59:7:532-534; 4 ref; 1980.

A laboratory method is described for the measurement under water, of the abrasiveness of a coal as it affects wear in pulverizers. The coal is ground by a rotating blade containing radioactive material. The determination of the level of radioactivity on the ground material provides an indication of the amount of material abraded from the blade. A coal which caused excessive wear in commercial grinding in a pin-disc mill gave an extremely high 'abrasive index' when subjected to this laboratory test. Abrasive indices have been determined for a series of New Zealand coals. High values correlate with increased ash level, with a high silica-to-alumina ratio in the ash and especially with a high free-silica content of the coal. (Authors)

1416. Wahl, W. "Reducing cost of wear"; Aufbereit Tech 20:10:559-566; 14 ref; (German); Oct., 1979.

Most varying wear parts are subject to premature abrasion in process engineering. At the same time, they have to withstand heavy mechanical stresses.

Therefore, using highly wear-resistant but brittle materials is limited. However, compound solutions enable the application of relatively brittle materials which have been combined with a tough base material. This results in longer service spans.(Author)

1417. Ueda, H. "Liner in grinding mill"; U.S. Patent 4,200,242; 1980.

1418. Shcherbakov, O.K.; Red'kin, G.N.; Balashov, G.V.; Budilova, E.A.; Dyatlova, S.F.; Filippova, T.F.; Baguzin, V.I.; Malkus, O.M. and Shevlyakov, M.I. "Reducing the consumption of grinding bodies in the comminution of ore"; Obogashch Rud Chern Met 8:57-63; (Russian); 1979.

1419. Lebedev, A.N.; Shcherbakov, O.K. and Balashov, G.V. "Corrosion-erosion wear of steel under conditions involving the operation of ore-grinding equipment"; Zashch Met 16:3:327-30; (Russian); 1980.

Different types of steel are used to study the fraction of overall wear accounted for by electrochemical corrosion during grinding. Results show that this fraction is greater than or equal to one-half of the overall wear of the steel used. Tests also reveal that corrosion inhibitors sharply decrease the consumption of the metal.

GRINDING MEDIA

1420. Thome, Michel "Crushing bodies forged from steel and a process for manufacturing same"; British Patent 2,024,860; 3pp.; Jan. 16, 1980.

1421. Tamai, Y.; Tomita, A. and Takarada, T. "Grindability of coal treated with liquid ammonia"; Nippon Kagaku Kaishi 6:951-958; 9 ref; (Japanese); 1980.

1422. Jacox, G.G. and Farge, J.C. "Recent developments in the production and testing of grinding media"; Can Min Metall Bull 73:815:205-210; March, 1980.

The effect of composition and process variables on the properties of Marmet and modified Ni-Hard slugs will be discussed. The effect of shape on the over-all performance of grinding media and its relationship to the end product has been investigated and these results will be reviewed. The cost effectiveness of slugs versus balls has been well documented under various operating conditions and this will be presented in detail. (Authors)

CLASSIFICATION

1423. Mandrella, H. "Tendencies in the development of modern screens"; Min Mag 142:3:242-244; 1980.

The various factors taken into account in the design of resonance screens, and the ways in which the screens themselves have evolved in consequence, are discussed in this article. (Author)

1424. Wills, B.A. "Factors affecting hydrocyclone performance"; Min Mag 142:2:142-146; 1980.

The hydrocyclone, in recent years, has proved to be one of the most versatile and useful tools in mineral processing applications. Cyclones have replaced mechanical classifiers in many modern grinding plants, as they are more efficient, especially in the finer size ranges. They also require less floor space, and consume less power. This article discusses the factors which affect their performance. (Author)

1425. Anon. "Low-cost hydrocyclone uses modular design and offers easy cleaning"; S Afr Min Eng J 90:4154: 82,84; Sept., 1979.

A mineral processing consultant formerly at the University of Bristol in Britain, Mr. R.H. Mozley, has designed a new small diameter hydrocyclone that is inexpensive and especially well suited to multiple assembly. The unit is easily cleaned, either manually or automatically. The components of the 25 mm diameter cyclone can be selected to give a particle size diameter cut point from 2 to 20 microns. Higher cut points can be achieved with the 50 mm diameter version, which is built up from the smaller one.(Author)

1426. Kar, D.D. and Sen Gupta, P. "Relative performance of baffled and unbaffled fluidised-bed-classifiers"; Indian J Technol 16:12:507-512; 1978.

The performance of batch fluidized bed classifiers (baffled and unbaffled) has been adjudged on the basis of the equilibrium bed concentration (C_E) or the retentive capacity of the bed for the finer or lighter component. Also, empirical relationships have been developed for predicting C_E and the separation efficiency (in terms of coefficient of perfection) by correlating these with the relevant parameters. (Authors)

1427. Bandopadhyay, A.R. "Operation of hydrocyclones"; Indian Min Eng J 18:12:13-14; 1979.

1428. Bedick, Robert C.; Patankar, Uday and Commins, James A. "Techniques for automatic aggregate gradation"; USNTIS PB Rep 80-175110: 147 pp.; Feb., 1980.

This study focuses on an evaluation of techniques for automatic gradation applicable to mineral aggregate used in highway construction. The impetus for this study was the need for improved, rapid information on aggregate gradation for process control and to facilitate producer certification of highway aggregate.

Potential techniques were identified after an extensive search of methods and concepts for automatic particle sizing spanning a wide spectrum of industrial activity where such information is needed for quality or process control. An elimination process narrowed the field of potential sizing techniques to six which were subjected to rigorous study. Two of these six techniques were identified for development of a conceptual system design which included technique modification, system component identification, structural considerations, compatability with existing plant equipment, system reliability analysis, cost estimates and analysis of technique limitations.

Conclusions from this study are that while no commercially available technique meets all the industry specified criteria for automatic gradation, the two systems identified (the vidicon and the optical shadow technique) show promise of being viable in the long run. It is recommended that further work, including engineering model development and field testing be undertaken to improve the performance capability of these techniques, and that alternate gradation specifications based on other measures of particle size be developed to facilitate the inclusion of these techniques in the industry mainstream. (Authors)

1429. Giles, W.B. and Bekofske, K.L. "Laminar flow cyclone development program. Quarterly technical progress report, October 1 - December 31, 1979"; U.S. Dept Energy Rep FE - 3242 - 15; 6 pp.; Jan., 1980.

The principal constraint to high Reynolds number operation is due to boundary layer instability in the radial inflow region. Therefore, a modified model has been built to study the influence of inlet wall heating with the water flow model. Also, a higher facility flow capacity now allows experiments at higher Reynolds numbers. (Authors)

1430. Helmuth, R.A. "Phase 1: Energy conservation potential of portland cement particle size distribution control. Progress Report, May-July 1978"; U.S. Dept Energy Rep COO - 4269 - 1; 22 pp.; Oct., 1978.

1431. Holynska, B.; Lankosz, M.; Ostachowicz, J.; Cynien, B.; Jaskulski, Z. and Widera, K. "New analyzers for continuous particle-size measurements of copper ore slurries"; Proc 13th Int Mineral Processing Congr; edited by J. Laskowski; June 4-9; Warsaw; Part B: 1598-1618; 1981.

The paper presents two particle-size analyzers for measuring the yield of a size fraction finer than 75 microns in copper ore slurriers.
In the first analyzer two radioisotopic x-ray sources ^{238}Pu and ^{241}Am of different energies were used for the excitation of copper in slurry. The influence of variation in solid content and particle size distribution on the results of measurements were studied.
In the second analyzer of simple construction the elutriation method was used. The results of laboratory investigations and trials in a concentrator are presented.
The two analyzers assure continuous monitoring of particle-size in copper ore processing plants. (Authors)

1432. Barari, H.B.; Sen, P. and Sen Gupta, P. "A generalised approach for multi-component multi-stage separation efficiency"; Min Eng (NY) 31:11:1618 (Abstract only); Nov., 1979.

A critical review of the various separation efficiencies reported in the literature has been made. Most of the relationships used for evaluating the performance relate to screening, classification or concentration operations and are applicable to single-stage, two component systems only. In the present work, a much simpler approach has been used for assessing the separation process irrespective of the type of operation and this has been extended further to obtain an expression for a multi-component feed and multi-product (from a multi-stage operation system.) (Authors)

1433. Luckie, P.T. "Classifiers in dry grinding circuits"; Proc AIME Annu Meet; Las Vegas; Prepr No 80-123; 15 pp.; 1980.

1434. McLaughlin, D. "Operation of an optical ore-sorting system"; Min Congr J 66:4:26-28; 1980.

1435. Parida, A. and Chand, Prem "Turbulent swirl with gas-solid flow in cyclone"; Chem Eng Sci 35:4:949-954; 10 ref; 1980.

Two-phase gas-solid flow in cyclone has been investigated to determine the effect of particles on the swirl velocity distribution. With the help of two-phase Navier-Stokes equations, the swirl velocities of the fluid and the particle phases have been evaluated theoretically by numerical schemes. The results highlight the effect of momentum coupling between phases, causing a significant change in the velocity profile with variation of particle size and concentration. The theoretical predictions reasonably agree with experimental results. (Authors)

1436. Bayvel, L.P. "Particle size distribution measurements in the submicron radius range by the method of spectral transparency"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 1:380-387; 3 ref; 1980.

The method of spectral transparency was investigated. A device for measuring particle sizes based on this method was developed, tested and applied. The device affords measurements of particle size distribution in the range from 0.1 to 4 microns. It proved possible to measure sizes not only of spherical particles but also of non-spherical ones. The spectral range in which it is necessary to determine transparency for particle size measurements was found. (Author)

1437. Sen, P. "Separation of subsieve size particles from suspension"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 2:1643-1660; 7 ref; 1980.

Frequently during the processing of minerals very fine particles are generated which are difficult to recover by conventional separation techniques and are rejected with waste water from mills. A method has been evolved for the continuous recovery of such fines by allowing the suspensions to flow through a rotating cylinder. Theoretical analysis of the trajectory of particles have shown that the efficiency of separation increases with R.P.M., tube diameter, particle diameter and density. Experiments carried out with the overflow from a hydrocyclone containing particles in the size range of 2-10 microns gave a separation efficiency of 60-70% with an R.P.M. of 3500 of the rotating tube. (Author)

1438. Burghardt, O. and Kortmann, H. "Investigations into wet sieving of fine ores in the fine grain range"; Arch Eisenhuttenwes 51:3:101-108; (German); 1980.

Introduction of a mechanical wet sieve analysis instead of the so far usual manual wet sieve analysis in the fine grain and finest grain size range of iron ores. Improvement of machine sieving by aeration of the individual sieves and by measuring the sub-sieve fraction with determination of the end point of sieving. Development of a procedure for making a sieve analysis also with relatively large sample sizes. Successful completion of the reproducibility tests within the laboratory of the authors and also by co-operative investigations in several laboratories. (Authors)

1439. Musialik, M. "Role of classifiers in the grinding of cement"; Cem Wapno Gips 2:36-38; (Polish); 1980.

Characteristics of the classifier utilized in cement grinding to low fineness, not exceeding 3000 cm^2/g Blaine, have been presented. It has been stated, that the utilization, so little intensive, of the classifier for this purpose is unjustified of the technological view-point. (Author)

MODELLING, KINETICS AND PROCESS CONTROL

1440. Kruczek, Stanislaw and Teisseyre, Miecyslaw "Method of calculating the energy required for the pulverization of brittle materials"; Przegl Mech 38:21:21-23; 3 ref; (Polish); Nov. 1, 1979.

1441. Garner, K.C.; Vanaswegen, P.C. and Smit, J.D. "Digital computer control of the milling circuit at Buffelsfontein Gold Mining Company Limited"; J S Afr Inst Min Metall 80:4:151-155; 1980.

The initial results obtained from the implementation of computer-controlled strategy on the milling circuit are reported. An analysis of these results showed that a peak-power pebble-mill controller on a high-throughput hard-rock wet-milling circuit reduces the stability of the system. It was concluded that the milling circuit should be regarded as a single system in which the measurement of grinding efficiency, circulating load, product size distribution, and feed rate should minimize the product variance and maximize the feed rate according to the grinding power available. Work is proceeding on such a system. (Authors)

1442. Fewings, J.H. and Wickham, P. "Centralised control of a mineral processing plant using a digital computer"; Proc 16th Conf Application of Computers and Operations Research in the Mineral Industry AIME; Tucson; 579-593; 3 ref; 1979.

Concern about maximum use of existing resources prompted the installation of upgraded instrumentation and computer control of grinding. Once the computer was paid for by financial returns from the project, computer control of other processes, including crushing and flotation, was economically viable. This paper discusses the benefits of the control systems and process control computer selection and application criteria.

1443. Keviczky, L.; Banyasz, C.; Hilger, M. and Kolostori,J. "CAD of closed-circuit mills"; Int Fed Automatic Control Symp on Computer Aided Design of Control Systems; edited by M.A. Cuenod; August 29-31; 1979; Zurich, Switzerland; 497-503; 1980.

1444. Maripuu, R. "Computer control of the Kristineberg ore dressing plant"; Proc 16th Conf Application of Computers and Operations Research in the Mineral Industry AIME; Tucson; 549-559; 2 ref; 1979.

Computer control of the ore dressing plant includes control of grinding (rod and pebble mills), on-stream x-ray analysis, and flotation control

1445. Thomas, Ralph E. "Statistical correlations on coal desulfurization by crushing and specific gravity separation"; Proc Symp Coal Clean Achieve Energy Environ Goals EPA - 600/7 - 79 - 098A PB - 299383; 1978; 1:448-63; 1979.

1446. McIntyre, A. and Plitt, L.R. "The interrelationship between Bond and Hardgrove grindabilities"; Can Min Metall Bull 73:818:149-155; 1980.

Both the Bond and the Hardgrove grindability tests are widely used in the mineral industry to measure the ease of the comminution displayed by a material. The Hardgrove test is mainly used for coals, whereas the Bond grindability test is mainly applied to hardrock minerals. The Bond grindability has the advantage that it can be empirically related to the energy required for comminution (work index), whereas the Hardgrove grindability test has the advantage of being easier to perform. In an effort to establish a valid

correlation between work index and Hardgrove grindability, a series of parallel grindability tests were carried out on a wide variety of rocks and minerals. The standard Hardgrove test was modified to allow for materials with a higher density than coal. A new, satisfactory relationship was established which permits rapid estimation of work index from Hardgrove test data. (Authors)

1447. Flavel, M.D. "Energy mathematics for crushing applications and systems for optimising comminution costs"; Proc AIME Annu Meet; Las Vegas; Prepr No 80-131; 130 pp.; 1980.

1448. Schaap, W. "Illustrated liberation-flotation recovery model for a disseminated mineral in low-grade ore"; Inst Min Metall Trans Sect C 88:C220-C228; 14 refs; Dec., 1979.

A quantitative model for mineral liberation based on one-dimensional considerations is extended by reference to the formation of composite particles - in particular, those in which the mineral part is occluded. On account of the assumptions made, the model is for inferential purposes only. The calculation of a single parameter, termed "effective grain size", from the results of a standard grinding and flotation experiment is proposed: thus, the liberation and recovery of the mineral at other grinds can be estimated. An illustration of the liberation model, when coupled to an extremely simple rougher-scavenger flotation model, with published operating data from Bougainville, indicates its potential effectiveness. Low grade ore bodies with one predominant valuable disseminated mineral may be better characterised at the evaluation stage, if this effective mineral grain size is considered together with the grade and hardness of the ore. (Author)

1449. Inoue, T. and Imaizumi, T. "Simulation of closed-circuit wet grinding process"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 1:126-147; 5 ref; 1980.

A simulation model has been developed to find out the possibility of improving the industrial closed-circuit wet grinding operations. The model involves a continuous tumbling mill in combination with a hydrocyclone to recycle the oversize material back to the mill. The mill is described by the breakage, i.e. the selection and the distribution, functions, co-ordinated with the diffusional mixing along the axis. The cyclone

classifier is characterized by the partition function with allowance for the non-selective separation of part of the feed material into the underflow.

The computer program developed incorporates an interactive capability to modify the operating conditions of the system whenever needed.

The results are analysed for the operational conditions characterizing the mill and the classifier. Besides the steady state conditions some observations are also made about the dynamic responses of the closed circuit grinding system. (Authors)

1450. Yastrebov, K.L.; Sergeev, Yu.A.; Bol'shakova, T.P.; Morozov, Yu.G. and Chirkova, V.M. "Improving the method of physical modeling the process of wet ore self-crushing"; Izv Vyssh Uchebn Zaved Tsvetn Met 6:3-7; (Russian); 1979.

1451. Aziz, J.A. and Schonert, K. "Single-particle size reduction and bed loading conditions for cement clinker fractions"; Zem Kalk Gips 33:5:213-218; (German); 1980.

The difference and the transition between single-particle size reduction and the loading conditions in a bed of particles are investigated. Single-particle size reduction exists so long as the proportion of solids in the comminution compartment does not exceed ten per cent in the case of approximately uniformly distributed particles. The deformation behaviour of a bed of particles is not affected by the boundary walls if the diameter is at least twice the height and the height is five times the particle size. A three-particle layer already displays the size reduction behaviour of a bed. The energy absorbed by a sample (single particle or bed of particles) is determined by the pressing resistance, which depends on the size and arrangement of the particles: the smaller these are, and the denser their arrangement, the higher will be the pressing resistance and the more difficult the energy input. In a bed of particles the proportion of particles fractured remains below unity i.e. not all the particles are broken down. The fracture function (size distribution of the fragments) of the particle bed loading possesses a higher fines proportion, but the absolute production of fines remains less than with single-particle size reduction. Hence the energy utilization (new surface produced per unit of work done) for the single particle is better than for size reduction of particles in a bed. (Authors)

APPLICATIONS

1452. Sentyurina; L.N.; Lutsenko, G.A. and Sviridova, M.A. "Grinding of molybdenum disulfide and graphite in impact-deflecting mills"; Khim Tekhnol Topl Masel 2:23-5; (Russian); 1980.

Complications in the form of aggregation of particles and severe contamination arise when grinding molybdenum disulfide and graphite, for use as lubrication in a ball or vibration mill. An alternative method of grinding - impact-deflecting mills - is discussed.

1453. Titarenko, A.I.; Pavlyuchenko, A.N.; Sandler, R.A. and Voleinik, S.N. "Oxidation of sponge titanium in crushing"; Tsvetn Met 4:61-4; (Russian); 1980.

Except for jaw crushers, industrial mills allow sponge titanium to be crushed without signs of being oxidized. Jaw crushers can be used however, when the sponge titanium has a porosity of greater than seventy percent. In studies of the optimization of crushing, crushing rates must be matched with porosity in order to prevent oxidation.

1454. Dimova, I.; Khristov, V.; Dodov, N.; Bogdanov, A.; Syev, S. and Georgiev, I. "Improvement in the grinding system at the "Medet" concentrating mill"; Tsvetn Met 3:103-7; (Russian); 1980.

Comminution of the copper-molybdenum-pyrite ore is difficult because of the characteristics of the ore. A two-stage process is studied involving rod mills in open cycle and ball mills in closed cycle. The increase in productivity of aggregate after introduction of higher rpm for the rod mills was found to be 7% above the projected value.

1455. Feige, F. "Investigations on the grinding of limestone in a high speed roller mill"; Zem Kalk Gips 33:5:223-225; (German); 1980.

The comminuting action upon granular layers in a high-speed roller mill is effected in fractions of a second. The attainable specific energy demand is lower than in a tube mill. The agglomerate formation is inherent reduced by using moist limestone. (Author)

1456. Decasper, J. "Comparison between roller mills and ball mills for cement raw material grinding"; Zem Kalk Gips 33:5:219-222; (German); 1980.

A comparison of the operating results of roller mills and ball mills employed in raw material grinding at seven cement works of the "Holderbank" group shows that the installation of a roller mill represents an economical solution. The absolute savings percentage in respect of operating and maintenance costs varies greatly from one work to another. It is, however, important to note that a reduction in costs was effected in all the works concerned. The operating experience that has been gained over a number of years confirms the advantage of the roller mill as regards specific power consumption and drying performance. The analysis of the operating problems in the respective cement works shows further that the originally very disconcerting design and maintenance problems have been solved. This is chiefly a result of the very close co-operation between the cement works and the suppliers of the mills. When designing a roller mill intended for service in a developing country it is necessary, in connection with plant maintenance especially to take account of local conditions such as the level of personnel training, availability of spare parts and technical advisory possibilities. (Author)

1457. Dao, D. and Sieling, A. "Contribution to the millability of a kaolin rich in muscovite"; Silikattechnik 30:11: 338-341; (German); 1979.

1458. Tagawa, I. "Apparatus for crushing building materials"; U.S. Patent 4,196,862; 1980.

1459. Ulakhovich, V.A. and Kotov, AP. "Comminution and stabilisation of coke in transit to the blast-furnace plant"; Coke Chem USSR 6:30-35; 5 ref; 1978.

The above 80 and 80-60 mm size fractions are mostly comminuted to the 60-40 and 80-60 mm ranges, the physico-chemical properties of which are closely comparable. The best method of improving coke quality and size uniformity is to apply a combination of crushing and abrading loads. (Authors)

1460. Kovalyukh, V.R. and Gud, M.B. "Operation of ball mills on coals of poor flowability, using the principle of vibratory transportation"; Therm Eng(USSR) 26:12: 722-724; 1 ref; 1979.

1461. Fabian, H. "Fields of application of mobile crusher installations"; Aufbereit Tech 21:6:277-284; 1980.

The design, manufacture and sale of mobile crusher installations requires long and varied experience and a wide range of different concepts for different markets. This paper contains an overview of the principal designs and explains their specific technical features.

The chemical and physical properties of the quarried material dictate the type of crushing machine to be employed. The position of the quarry face, the scheduled quarrying rate, the condition of the floor of the quarry and the distance from the processing area influence the crusher undercarriage and the conveyor designs. There are crushers with well proven undercarriage types on the market, namely

- crawler undercarriages,
- rail-bound undercarriages,
- hydraulic walking mechanisms,
- separate transport crawler units,
- fully mobile pneumatic-tyred undercarriages.

Another concept is now added to the above conventional crusher types. It is the semi-mobile crusher with a pneumatic-tyred undercarriage. It ideally combines the merits of mobility with the advantages of a stationary unit. The crushers of this type can be assembled of modules to form machines specifically suitable for their intended applications. (Author)

1462. Kok, H.G. "The use of mobile crushers in the minerals industry"; Proc AIME Annu Meet;Las Vegas; Prepr No 80-91; 12 pp.; 1980.

1463. Motz, J.C. "Plant design considerations for cone-crusher applications"; Proc AIME Annu Meet; Las Vegas; Prepr No 80-146; 10 pp.; 1980.

1464. Husemann, K.; Topfer, E. and Scheibe, W. "Strain phenomena in pin mills"; Aufbereit Tech 20:10:551-558; (German); Oct., 1979.

The strain phenomena occurring in pin mills up to now have been explained rather unsatisfactorily. The process of comminuting as it takes place in pin mills is illustrated; variables, operating principle and velocity ratios in the action zone between the rotors are determined. Furthermore, solids concentration in this zone, opportunities of impact and number of impacts are evaluated and conclusions in respect to strain phenomena are drawn.

The use of mass-balance models in analogy to ball mills has not always been possible in pin mills. The processes were modelled on the basis of the general transport equation of process engineering for integral transport variables and described by dimensionless parameters. This method serves as basis for designing and scaling of pin mills and may also be applied to other grinding mills. (Authors)

1465. Magalhaes, Gustavo "Preparing anatase with the proper particle-size distribution"; Braz. Patent 78 00586; 10 pp.; (Portuguese); August 21, 1979.

1466. Ocepek, Drago "Some problems of mechanical treatment of iron ore in dressing"; Metalurgija (Sisak, Yugosl.) 18:1:3-8; (Serbo-Croatian); 1979.

Two problems are discussed in this paper: 1)Optimizing ore crushing process with the aim of getting optimum granulometric size at minimum energy consumption and amount of ore which is to be sintered later on. 2)Optimizing washing process for ores with clay constituents defined by washability characteristics of ore and washing characteristics of washing machine. Results of original experiments are given to show the possibilities of finding the optimizing equation by means of regression analysis for both processes. (Author)

1467. Malmberg, Bo "Concrete with crushed aggregate -- An inventory of the literature"; CBI Forsk 7:86 pp.; 40 ref; (Swedish); 1979.

1468. Moulin, G. "Central coal drying-grinding plant for the lime kiln of Gecamines in Kakontwe (Zaire)"; Tech Mitt Krupp Werksberichte 38:1:41-44; (German); 1980.

1469. Rozhkov, A.K.; Kornienko, Ya.P. and Vaisberg, V.M. "Experiment in improving the technique and technology for grinding moist clay-containing ores"; Issled Protsessov Rudopodgotovki Obzhigmagnitn Obogashch Aglomeratsii I Okomkovaniya L 51-60;(Russian); 1979.

NOVEL METHODS

1470. Murti, N.S.S. and Seshadri, V. "On differential grinding"; Trans Indian Inst Met 33:1:67-69; 1980.

When a mineral is ground and sieve analysed, the chemical analysis of the different size fractions is found to differ. This is due to the difference in the grinding characteristics of the different constituents of the mineral. In the present work, an attempt has been made to investigate the possibility of using grinding characteristic for separation of the different constituents by controlled mill grinding. (Authors)

1471. Svarovsky, L. and Hadi, R.S. "A new simple and sensitive on-line particle size analyser for fine powders suspended in gases"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 1:366-379; 14 ref; 1980.

This is a report of a new development in on-line particle size measurement of fine powders in dust-laden gases.

A continuous sample of the solids-air suspension is drawn from the process stream via a sampling probe by means of an air operated ejector into a cydonic separator whereby the sample is subjected to a particle size dependent separation process and split into two streams, "overflow" and "underflow". The overflow stream carries most of the fines at a relatively low concentration and the underflow stream carries the coarse particles at a relatively higher concentration. The concentration of solids in the two streams is detected by electrostatic noise level technique which utilises the electrostatic charge accumulated on the solid particles due to their high velocity in the turbulent air stream, for the mass concentration measurement. The ratio of the solids concentration of the fines stream to that of the coarse stream is then correlated against the average particle size in the main process stream by a calibration curve.

The in-plant tests clearly indicate that this relatively simple instrument offers good sensitivity in the size range from 2 to 6 microns and is capable of giving a continuous indication of average particle size for process control purposes.

Although the instrument was developed for a particular application, it may be used in other situations where fine powders are conveyed in gas streams. British and foreign patents are applied for. (Authors)

1472. Trass, O. "The Szego grinding mill"; AIME Int Symp on Fine Particles Processing; edited by P. Somasundaran; February 24-28, 1980; Las Vegas, Nevada; 1:96-112; 4 ref; 1980.

The mill body is a stationary grinding cyclinder inside which a number of helically grooved rollers rotate, each being suspended on a flexible axis. The feed material is repeatedly crushed between these rotors and the cylinder, with the crushing force created by radial acceleration. The mill has several internal design variables such as number, size and shape of rotors, and can be operated wet or dry. It is compact, has a high capacity, modest power consumption, and can grind many materials down to ultrafine powder. Illustrative data on product size distributions and particle shapes are given for grains, metals and minerals obtained at various operating conditions, along with initial results on grinding kinetics. (Author)

CANMET QUARTERLY BIBLIOGRAPHY OF CRUSHING AND GRINDING- OCTOBER/NOVEMBER/DECEMBER 1980

D.G. Vandenhoff

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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	93:10-22; 1980
METADEX (Metal Abstracts)	80:10-11; 1980
NTIS (National Technical Information Service of the U.S. Dept of Commerce)	80:22-26; 1980
SCIENCE CITATION INDEX	80:36-47; 1980
COMPENDEX	80:8-12; 1980

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	13:10-12; 1980
IMM ABSTRACTS	Oct./Dec. 1980

References are numbered sequentially and are grouped according to the main topics shown below. Not all topics need to be presented in any one report.

A) Review articles
B) Crushing
C) Rod and ball mill grinding
D) Autogenous, semi-autogenous and pebble grinding
E) Liners and wear
F) Grinding media
G) Classification
H) Modelling, kinetics and process control
I) Fracture
J) Applications
K) Novel methods

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REVIEW ARTICLES

1473. Cadle, Richard D. "A review of particle size analysis"; Test Charact Powders Fine Part; edited by J.K. Beddow and T. Meloy; 56-65; 24 ref.; London, England, Heyden; 1980.

1474. Hofmann, F. "Comminution"; Fortschr Ver fahrenstech Ser B 18:131-140; 1980.

1475. Anon. "Focus on mills, grinders and crushers"; PACE Process Chem 33:2:23-32; 1980.

CRUSHING

1476. Laura, P.A.A.; Pombo, J.L. and La Malfa, S. "Dynamic behaviour of an ore mill foundation and its vibration prevention"; Appl Acoust 13:1:1-6; 2 ref.; January-February, 1980.

The present paper deals with an experimental investigation of the excessive vibration generated by a particular ore-mill during operation.

The out-of-balance forces of the crushers are horizontal and induce a rotational motion of the entire system around a vertical axis. Since the resulting motion is not deterministic in nature a solution based on a dynamic absorber type principle is not possible.

An experimental model which represents the most important geometric and mechanical parameters has been developed and constructed at the authors' Institute.

Several economically convenient engineering solutions, designed to reduce its vibrational level, have been devised for the laboratory model. The solutions consist of adding damping and/or stiffness to the foundation in an inexpensive fashion.

Finally, the paper discusses the feasibility of implementing the laboratory solution on the real case. (Authors)

1477. Kothari, Atul and Gerstle, Richard "Air pollutant control techniques for crushed and broken stone industry"; US NTIS Rep PB 80-222656 (EPA- 450/3-80-019); 270pp.; May, 1980.

Air pollutant control technologies for the control of particulate emissions from crushed and broken stone production facilities are evaluated. Specific control technologies considered include the use of local ventilation followed by fabric filter collection and wet dust suppression techniques. Performance data based on mass particulate measurements and visual observations are presented. In addition, the capital and annualized emission control costs for several model plant sizes are estimated. The environmental and energy impacts associated with each control technology evaluated are also presented. Alternative regulatory options available are identified and evaluated in terms of their enforceability, impact on the environment, cost and impact on energy. (Authors)

1478. Elmquist, S. "How to evaluate cone crushing circuits"; Eng Min J 181:9:122-129; 1980.

1479. Pankov, P.I.; Yugova, E.D. and Maksimenko, T.N. "Comparative testing of roll and hammer breakers used for tin-tungsten ore";Kolyma 3:8-10; (Russian); 1980.

1480. Neiman, I.B. "Determination of dimensions of the zone of crushing of rock in place by blasting"; Sov Min Sci 15:5:480-485; 1979.

1481. Miller, Harold J.; Laughbaum, Edward E. and Fisher,Wm. R. "Portable crusher for underground mining applications and design. Phase 1-Design"; US NTIS Rep PB 80-227515 (BUMINES - OFR - 100 - 80); 111 pp.; August 31, 1978.

This report summarizes proposals and findings made in conjunction with the newly designed M-44 low head portable crusher which is believed well capable of meeting the requirements of a "portable, underground, hard rock" machine as previously defined in earlier reports. Data gathered by use of the ½-scale model of the M-44 has substantiated and verified the concept sufficiently to justify construction of a full-size machine for further testing under actual mine conditions. (Authors)

1482. Urosevic, D. and Jankovic, D. "Technical solution of complex dedusting as exemplified in the section for ore crushing, screening and transportation at the Veliki Krivelj copper mine"; Rud Glas 4:49-56; (Serbo-croatian); 1979.

In addition to the harmful effect of aggressive mineral dust on the health of the labor force, the paper also outlines the application of complex measures related to protection against the dust.
The authors outline the technological principles of application of complex protective measures in mineral dressing plants exemplified by the copper mine Veliki Krivelj. (Authors)

1483. Jackson, A. and Kaja, D.M. "Elastohydrodynamic lubrication in a gyratory rock crusher"; ASLE Trans 23:3:298-304; 1980.

The highly loaded gyrating contact in the top bearing of a gyratory rock crusher is analyzed and found to operate in the elastohydrodynamic lubrication regime. The analysis is of interest from a number of viewpoints:
a) The contact rotates around the bush as the crusher gyrates, creating a rolling contact of high speed.
b) The elliptical contact is aligned with its long axis parallel to the rolling direction, which is unusual.
c) Due to high loads and large radii, the elastic contact ellipse is very large (39.2 cm x 10.5 cm) by EHL standards.
d) The calculated film thickness is of the order of 20 microns which is large in EHL terms, but leads to a low value of 0.15 when compared with roughness extrapolated to a cut-off length of twice the contact length as recommended in the literature. The bearing has been operating without distress for a year which is at variance with the low value. (Authors)

1484. Tsvetkov, V.M. and Lukishov, B.G. "Fragment formation in crushing a brittle medium under hydrostatic compression"; Sov Min Sci 15:3:228-232; 6 ref; 1979.

1485. Pyatskur, V.K. and Martynenko, N.G. "Superior working efficiency of crushing equipment"; Gorn Zh 7:27-28; (Russian); 1980.

1486. Faulkner, I.A. "In-pit crushing: a review of technicues, equipment and practice"; Quarry Manage 7:6:159-168; 1980.

ROD AND BALL MILL GRINDING

1487. Kovalyukh, V.R. and Gud, M.B. "Identification of ball mill"; Izv Vyssh Uchebn Zaved Priborostr 22:11: 28-31; 4 ref; (Russian); November, 1979.

1488. Beke, B. "Can the grinding effectiveness be improved?"; Epitoanyag 32:6:209-213; (Hungarian); 1980.

It is unjustified, both from theoretical and practical aspects, to express the efficiency of grinding as being in correspondence with the developed excess surface energy. A good practical information on energy utilisation is the ratio between the energy consumption of single corn breakage and industrial grinding. Although grinding devices operated by slow compression and surface abrasion are superior from the point of energy utilisation to ball mills, their application for high-capacity industrial equipment requires still long development activity. (Author)

1489. Chielsen, A. and Marshal, G. "Large Shoe-mounted ball mills"; Rock Prod 83:6:84-88; June, 1980.

1490. Kanda, Yoshiteru; Hoshi, Yasuhiro; Hirata, Koichi and Takeuchi, Hidetoshi "Specific surface increase during ball mill grinding"; Zairyo 29:324:873-5; (Japanese); 1980.

An experimental study was carried out to obtain the solid surface increase produced in the ball mill grinding. The samples used were silica glass, quartz, feldspar, limestone, marble and talc. The pebble mill consisted of a cylinder of 12.5 cm diameter by 12.5 cm long and 35 balls of a 2.8 cm diameter having the total weight of 1000 g. The tests were done at the speed of 87% of critical one and with the feed size of 14-20 mesh and feed weight of 200 g. On the assumption that the shape factor is six, the specific surface was determined by the permeability method.

As the result, the stepped grinding curves were obtained for the relationship between the solid surface produced and grinding time. The grinding curve for closely elastic solids showed three steps, but it showed two steps for plastic solids. (Authors)

1491. Jungblut, G. and Peereboom, G. "Segregation in dust bins of electrode plants"; TMS Paper Selection A-79-25; 19 pp.; 1979.

1492. Kaminski, A.A. and Kaminski, A.D. "Theoretical considerations of grinding in multi-tube mills"; Tsement 7:14-16; (Russian); 1980.

AUTOGENOUS, SEMI-AUTOGENOUS AND PEBBLE GRINDING

1493. Rakitskii, V.I. "Characteristics of the self-grinding of gold containing quartz ores"; Tsvetn Met 7:41-4; (Russian); 4 ref; 1980.

1494. Khan, A. and Ramanujam, M. "Improved correlation for superfine grinding in a condux air jet-mill"; Indian Chem Eng 20:4:49-51; 1978.

Grinding tests are carried out on calcite in a condux air jet mill for varying feed size range, feed rate and air rate. The grinding ratio data are correlated in terms of the Reynolds number based on grinding nozzle, mass ratio of air to-solids in the feed and the ratio of mean feed particle size to mill size. (Authors)

1495. Cardini, Jean Louis "Apparatus and method for wet attrition"; Fr. Pat. Appl. 78/32217; Nov. 15, 1978; Eur. Pat. Appl. 11559: 15 pp.; (French); May 28,1980.

1496. Sentyurikhina, L.N.; Lutsenko, G.A. and Sviridova, M.A. "Milling of molybdenum-disulfide and graphite in impact-rebound mills"; Chem Tech Fuels Oils 16:1-2: 103-106; 7 ref; 1980.

1497. Homma, Torajiro; Hasegawa, Masahiro and Asaba, Yoshiyuki "Effect of various factors on grinding using jet mill"; Kagaku Kogaku Ronbunshu 6:5:527-32; 12 ref; (Japanese); 1980.

The holdup of particles, the size distributions and the specific surface area of products were investigated experimentally using a micronizer-type jet mill. A mill of 100 mm diameter was made based on Rumpf's design data. Six kinds of samples- limestone, quartz, and several solids-were used in grinding experiments.

It was found that the holdup was affected by the grinding conditions. The specific surface area produced was found to increase with -0.25 power of feed rate and to be proportional to the total air rate through the nozzles. An experimental equation between a grinding ratio R_G' (the ratio of specific surface area produced to that of feed) and non-dimensional groups

consisting of factors such as feed rate, feed size, total air rate and nozzle diameter was obtained. (Authors)

1498. Akunov, V.I. and Yudovich, B.E. "Jet-mill grinding products: surface and grain composition"; Tsement 7:11-13; (Russian); 1980.

LINERS AND WEAR

1499. Wight, H.H. "Failure of hammers in a hammer mill reduced by nondestructive testing"; Proc 9th World Conf on Non-destructive Testing; November 18-23; Melbourne, Australia; 13 pp.; 1979.

1500. Verhey, Paul "Mineral processors can benefit from long life, high efficiency with ceramic liners"; Can Min J 100:11:43-44; November, 1979.

GRINDING MEDIA

1501. Anderegg, Charles M. and Moorer, Howard H. "Cement grinding aid and set retarder"; U.S. Patent 4,204,877; 6 pp.; May 27, 1980.

1502. Chung, Bok; Yang, Jae Yuhl and Lee,Soo Young "Regrinding efficiency of rougher concentrates in fine crystalline graphite flotation"; J Korean Inst Miner Min Eng 16:4:272-279; 7 ref; (Korean); December, 1979.

The laminar form of graphite of low specific gravity and natural water-repellence makes flotation of large particles possible. Ocassionally the fine size crystalline graphite should be required extremely fine grinding to produce high quality concentrates. Mechanical work index of graphite is so high that grinding efficiency is low.

The test was conducted to increase grinding efficiency by adding materials as a grinding aid to the secondary grinding circuit in graphite flotation. In this experiment, rougher graphite concentrates was ground in a rod mill with sand (rougher conc:sand= 4:1) as a grinding aid and screened to 150~325 mesh.

From the results of this research it can be concluded as follows:

1) Grinding efficiency can be elevated about 7%.
2) Grinding time can be shortened 20~30%
3) Graphite concentrate can be graded up to 2~4%.

(Authors)

1503. Cleemann, Joergen "Mills for efficient grinding with small grinding media"; World Cem Technol 11:4:179-185; 5 ref; May, 1980.

CLASSIFICATION

1504. Luzin, Yu.P.; Trukhina, V.T. and Golovan, G.S. "Destruction of dust in mechanical screening"; Ind Lab (USSR) 45:4:456-457; 2 ref; April, 1979.

1505. Vitek, Jan "Use of recent modifications of conductivity analyzers for measuring the particle size distribution of ore dusts"; Rudy 28:1:13-18; (Czechoslovakian); 1980.

1506. Lines, R.W.; Harfield, J.G. and Miller, B.V. "The measurement of particles up to 1.5 mm diameter by the Coulter principle"; J Powder Bulk Solids Technol 3:2:28-36; 1980.

The upper particle size measurable by the Coulter Counter has been limited by the ability to sample from a uniform suspension, using the standard aperture/sampling assembly configuration. A new configuration has been developed which allows particles of any specific gravity to be passed through the sensing zone from a selection of automatic feeders. When fitted to a multichannel Coulter Counter, 16-point size distribution analyses up to 1.5 mm have been made within a few minutes. The results on a range of materials are compared with sieving and microscopy. (Authors)

1507. Senden, M.M.G. "Performance of zigzag air classifiers at low particle concentrations: a study of the effect of stage geometry variations"; Proc 9th Natural Waste Process Conf ASME; May 11-14; Washington, D.C.; 351-359; 1980.

The separation performance of zigzag air classifiers with angles between the sections of 90 deg., 120 deg. and 150 deg. has been studied at low particle concentrations, both with respect to the single stage behaviour of particles and to the interaction between the stages. The influence of stage geometry on the single stage behaviour has been explained, based on an analysis of the air flow pattern and the particle trajectories. The exchange of particles between the stages has been described by a stochastic one-step-memory model which relates multistage performance to single stage characteristics. (Author)

1508. Barton, P.J. and Peverett, N.F. "Automated sorting on a South African gold mine"; J S Afr Inst Min Metall 80:3:103-111; 1980.

A brief review of the development and ultimate design of the Model 16 Photometric Sorter is given, including the differences between it and its predecessor, the Model 13, which is currently in operation at Doornfontein.

A description of the West Driefontein sorting plant is given, together with the rationale of its design. The installation programme for the sorters is described, and current operating and maintenace procedures are discussed. Operating results are tabulated and compared with the original test results. Operating costs are also discussed. (Authors)

1509. Ramaswamy, K.L. "Recirculation loads in copper concentrators with particular reference to Rakha copper plant"; Indian Min Eng J 18:10:11-14; 2 refs; October, 1979.

1510. Mandrella, H. "Extra-fine grinding of bulk materials"; Keram Z 32:1:24-29; (German); 1980.

It is claimed that a high specific throughput and sharp classification in the sieving of very fine gradings can be achieved in a machine with a so-called free-stroke impulse. The results of test sievings are given. (Author)

1511. Faddeenkov, N.N.; Bobrov, G.F. and Balagur, Ya.A. "Stability of fragment size characteristics"; Sov Min Sci 15:3:233-238; 1979.

MODELLING, KINETICS AND PROCESS CONTROL

1512. Horst, W.E. and Enochs, R.C. "Instrumentation and process control"; Eng Min J 181:6:70-95; 73 ref; June, 1980.

1513. Smith, H.W. and Guerin, D. "Dynamic modeling, simulation and control of a grinding circuit"; Can Min Metall Bull 73:821:133-138; 12 ref; 1980.

This paper describes the development of a dynamic model for a full-scale (64 tonnes/hr) grinding circuit consisting of an open-circuit rod mill feeding a ball mill operating in closed circuit.

The object of constructing such a model is to investigate the static and dynamic behaviour of potential control schemes. Model selection, data processing and parameter estimation are discussed, and static and dynamic results of simulations are presented. Conclusions are drawn with regard to the adecuacy of the model for such studies, and likely limitations on control of such circuits. (Authors)

1514. Kuyumcu, H.Z. "Mathematical-Statistical description of the crushing and stream classificatim of iron-ores"; Stahl Und Eisen 100:20: 1183-1187; (German); 1980.

Characteristics of the relationship between particle size distribution and chemical composition by means of the atomic number ratio. Mathematical-statistical description of the crushing of iron ore in a three-dimensional fractional representation. Factors of influence in the continuous crushing of iron ores in ball mills. Change of the distribution as related to throughput, mill rotation speed, particle size and crusher ball size. Stream classification of iron ores, spiral classification of iron ores. (Author)

1515. Meric, J.P.; Lejean, Y. and Caron J.F. "Continuous measuring equipment for a ball mill for fineness of elements by laser beam diffraction"; Ind Miner St.Etienne, Tech 1:3-11; 4 ref; (French); January, 1980.

1516. Jagadeesan, V.J. and Vedaraman, R. "The effect of operating variables on the grindability of materials"; Indian Chem Eng 21:2:44-46; 1980.

1517. Srikant, A. "Calculation of specific charge consumption from work indices"; J Mines Met Fuels 27:8:251-252; 6 ref; 1979.

The paper aims to relate the charge consumption in rock breaking to the energy required to cause the comminution of rock from infinite size. Rock factors and variability are taken into account in the form of a constant which varies with the rock. (Author)

1518. Kanjilal, K.K. and Chatterjee, D.R. "A study on the role played by the mineral constituents during grinding operation of coal by Hardgrove machine"; J Mines Met Fuels 27:7:215-220; 1979.

Increase in Hardgrove Grindability Index (HGI) in some low rank, fresh coals is observed to be due to presence of shale of high HGI whereas lowering of

HGI in some high rank coals from its normal value is found to be due to coal-shale inter-grown materials or shales of low HGI present in the sample in appreciable amount. (Authors)

1519. Faddeenkov, N.N. and Balagur, Y.A. "Mathematical model of changes in fragment size composition during ore mining"; Sov Min Sci 14:5:484-490; 22 ref; 1978.

1520. Crha, Z. "Use of regression analysis for evaluation of milling processes"; Pokroky Praskove Metal (2-3): 3-12; (Polish); 1979.

1521. Herrmann, H. "A general statistical method for correcting measured size distributions in classification processes"; Ger Chem Eng 3:4:217-222; 1980.

When a dispersed solid material (feed) is separated, e.g. by air classification, into fine and coarse fractions, the cumulative distribution curve of the particle sizes serves as a basis for characterization of the result and quality of separation. The procedures of the conventional particle size analysis are subject to a random error, so that on the one hand, the mass balances are incorrect and, on the other hand, the derived characteristics, in particular the separation curve, are determined with an unknown, but in most cases considerable error. The author wishes to present a mathematical method which takes into account the measurement errors of the cumulative curves and corrects them in such a way as to eliminate these errors from the mass balance. The corrected values contain no systematic errors, and the measurement errors of the initial values are to a much lesser extent reflected in the corrected values. On calculating the characteristic values it can be seen that this method provides a much more exact characterization of the separation.(Author)

APPLICATIONS

1522. Marchal, Gerard "Recent developments in coal grinding in French cement plants"; Pit Quarry 72:9:91-94, 126; March, 1980.

1523. Grudzinski, Janusz "Structure of coal dusts"; Przegl Gorn 35:12:545-53; 11 ref; (Polish); 1979.

1524. Krishnaswamy, N. and Subrahmanyam, N. "Studies on beneficiation of laterite. Part 1. Preferential grinding"; Indian Chem Manuf 18:5:22-6; 1980.

Laterite contains approximately 12%SiO_2, 8%Fe_2O_3 and 13%$Al2\ O_4$. Different studies are carried out to explore the possibility of utilizing laterite as a source of ore. Detailed investigations are carried out on the grinding and sizing processes for the beneficiation of laterite. A study also is made on the rate of grinding of laterite by attrition. It is found that the laterite can be enriched in its aluminum content by grinding and sizing. The work index for laterite size reduction is found to be 8.2. (Authors)

1525. Chashchin, I.P.; Frolova, G.S. and Bobrovskaya, T.M. "Problem of grinding solid materials"; Mineral'n Syr'e I Neftekhimiya, Tomsk 69-72; (Russian); 1977.

1526. Tatsuta, Mitsuo; Ono, Kazuo; Okaue, Hiromitsu; Ogawa, Tomohiro and Kosaki, Youichi "The influence of coarse coke on the grindability and burning condition of cement raw materials"; Rev Gen Meet Tech Sess-Cem Assoc Jpn 33:61-3;; 1979.

When carbonaceous substances are added to cement raw materials, it is known that their grindability is improved and that the fuel consumption for clinker burning is reduced. In this study, the effects of coarse coke (by-product in iron works) on the grindability of raw materials and burning condition were investigated. (Authors)

1527. Stuhlik, V. "Use of selective crushing technology in preparing a coal charge for coking"; Coke Chem 11:20-23; 5 ref; 1978.

An electrically heated screen has been designed in Czechoslovakia in the development of selective crushing to prepare a coal charge for coking. The screens have been adopted by many iron and steel works in Czechoslovakia. (Author)

1528. Levins, D.M. "Environmental impact of uranium mining and milling in Australia"; Can Min Metall Bull 73:822:119-125; 15 ref; 1980.

Australia has almost twenty per cent of the Western World's low-cost uranium reserves, located mostly in the Alligator Rivers region of the Northern Territory. At present, only one uranium mill is operating in Australia, but a number of new mills are planned for the early 1980s.

Details are given of Australian uranium mining and milling proposals and the measures taken to minimize their environmental impact. Major factors affecting environmental impact are discussed, including treatment of liquid wastes, water management, control of radon and other airborne releases, and disposal of tailings. (Author)

1529. Zisselmar, R. "Principles of calculating direct and indirect separator cooling effect in closed-circuit cement grinding plants"; Zem Kalk Gips 33:9:456-464; 13 ref; (German); 1980.

Essential chemical and physical properties of the cement as well as the grinding and classifying processes required for its production may be affected by increasing temperatures. In many cases it is, therefore, necessary to reduce these increased temperatures. For lowering the temperatures there are a number of appropriate cooling processes. A special feature of the cyclone air separator is that it can also be used as a cooling unit. Theoretical considerations taking into account the essential parameters lead to relations by which the temperatures of the finished product as well as of the mill discharge can be calculated, which are obtained by direct and indirect separator cooling. (Author)

1530. Fredenberg, K.G. and von Wedel, K. "Coal grinding and drying with vertical mill and inert gas circuit"; Zem Kalk Gips 33:9:446-451; 4 ref; (German); 1980.

A coal grinding plant for the cement works of the Swedish firm of Cementa AB at Slite, Gotland, was supplied by German cement works equipment manufacturers through French subsidiary companies and in collaboration with Swedish firms. The plant comprises a vertical grinding mill with circuit inertization for an output of 10 t of pulverized coal per hour. The design features, mechanical equipment and control technology of the plant are described. Trouble experienced in commissioning

the system is reported and analysed. With consistent application of the original plant concept and with inertization on starting and stopping this inertized installation constitutes an economical alternative to coal grinding systems designed with protective constructional features. (Authors)

1531. Liebler, W. "Experience with a slag cement grinding plant with pneumatic conveyor dryer"; Zem Kalk Gips 33:9:452-455; (German); 1980.

The firm of Dyckerhoff built a slag cement grinding plant in the port area of the town of Neuss and commissioned it in May 1979. It was designed for the closed-circuit grinding of blastfurnace slag cements at throughputs of 50-75t/hour, the slag being dried in a pneumatic conveyor dryer installed ahead of the mill. The mill, the dryer and the cyclone air separator were supplied by Krupp Polysius. This slag cement grinding plant is described and the experience gained in operating the dryer is reported in the article together with the results of measurements performed on the Cyclopol 45/4 cyclone air separator. (Author)

1532. Bank, Walter "Asbestiform and/or fibrous minerals in mines, mills, and quarries"; Inf Rep US Dep Labour Mine Saf Health Adm No. 1111, 27 pp.; 39 ref; 1980.

One theory of mineral-fiber-induced lung damage holds that the shape and size of the responsible inorganic materials are significant factors. Asbestiform minerals, fibrous minerals, or elongated cleavage fragments, irrespective of the mineral name applied or definitions employed may, therefore, become significant in a health evaluation of airborne dust. Many minerals in ore deposits and quarries exist in variable habits, including the fibrous shape. Names of such minerals vary, depending on locality, availability of analytical equipment and personnel, traditional usage, and other factors. Because of these factors workers in the mining and associated industries unknowingly may be exposed to asbestiform or fibrous minerals.

Appendix I lists many minerals that occur in asbestiform or fibrous habits or which tend to cleave into elongated fragments. Appendix II lists some selected mines, arranged by commodities and scattered throughout the conterminous United States, where fibrous minerals may be found. Actual mine visitations have confirmed the presence of such fibrous minerals. (Author)

1533. Giles, W.B. and Bekofske, K.L. "Laminar flow cyclone development program. Quarterly technical progress report, January 1- March 31, 1980"; U.S. Dept Energy Rep FE-3242-20; 23 pp., April, 1980.

The principal constraint to high Reynolds number operation is due to boundary layer instability in the radial inflow region. Therefore, a modified model has been built to study the influence of inlet wall heating with water flow model. This wall heated model of the radial inflow region has been adapted with additional thermocouples, plus insulation of the rim. The data continue to indicate highly stable flow conditions up to the maximum test Reynolds numbers. Work is continuing to further increase the system flow rate. (Authors)

1534. Luckie, P.T. "Coal grinding technology: a manual for process engineers"; U.S. Dept Energy Rep FE-2475-25; 98 pp.; 1980.

1535. Luckie, P.T. "Developing/modifying coal grinding procedures and equipment to produce predictable size distributions during coal preparation"; U.S. Dept Energy Rep FE-2475-26; 341 pp.; 1979.

CRUSHING AND GRINDING BIBLIOGRAPHY
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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	93:24-26; 1981 94:02-10; 1981
COMPENDEX	81:01-02; 1981
METADEX (Metal Abstracts)	80:12; 1981 81:01-02; 1981
NTIS (National Technical Information Service of the U.S. Dept of Commerce)	81:02-08; 1981
SCIENCE CITATION INDEX	80:48-52; 1981 81:01-07; 1981

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	14:1-3; 1981
IMM ABSTRACTS	31:1; 1981

References are numbered sequentially and are grouped according to the main topics shown below. Not all topics need to be presented in any one report.

A) Review articles
B) Crushing
C) Rod and ball mill grinding
D) Autogenous, semi-autogenous and pebble grinding
E) Liners and wear
F) Grinding media
G) Classification
H) Modelling, kinetics and process control
I) Fracture
J) Applications
K) Novel methods

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REVIEW ARTICLES

1536. Kjos, D.M. "Grinding circuits: Current status and projected future development"; Proc 52nd Annu Meet Minnesota Sect AIME; January 10-12, 1979; Duluth, Minnesota; 3:1-3:34; 14 ref.

The 1970's saw significant growth and a continued evolution in grinding mill sizes and types; a trend that started in the 1960's. During this period we saw giant 8950 kW (12000 Hp) primary autogenous mills designed, manufactured and successfully operated. Conventional rod and ball mill sizes increased also to 1715 kW (2300 Hp) and 5145 kW (6900 Hp) respectively. Then, the "energy crunch" of the 1970's forced an increased consciousness on the importance of efficient classification and automatic circuit controls to "squeeze" all the work out of a circuit that is being paid for.

The recent period has not been without problems for users and manufacturers. A great deal of process and design knowledge has been gained, however, that will provide a basis for more reliable mills and mill circuits in the future.

This paper will discuss milling trends of the last decade. Some of the accomplishments, problems and major influences on today's designs will be examined. Finally we'll try (with much trepidation) to look into the future. (Author)

CRUSHING

1537. Krogh, S.R. "Crushing characteristics"; Powder Technol 27:2:171-181; 11 ref; 1980

A method of measuring the basic characteristics of comminution was developed. These characteristics are expressed by the major comminution functions: crushing probability function, energy function and breakage function. The crushing probability function is the strength distribution of particles of a given size. The energy function is the strength of the particles as a function of their sizes. And finally, the breakage function is the size distribution of the crushed material. The functions are defined mathematically. Several natural minerals were tested

by drop tests in order to determine their individual comminution functions. From the tests, several crushing properties of the particulate materials can be derived. The comminution functions given in this paper would be the basic elements in developing mathematical models for various crushing and grinding processes. (Author)

1538. Schmidt, Gunther "Krupp Kubria cone crushers, Esch type - Their application as secondary/tertiary crusher units"; Erzmetall 33:7/8:383-386; 1980

After a brief review of previous models, design and operating methods of the Kubria cone crusher are described, the different models are introduced and, in conclusion, a report is given on the results obtained in trial runs and operational practice. An outstanding benefit of this new Kubria cone crusher is its electrohydraulic control system. After appropriate preselection, this control system permits automatic setting and variation of the crusher gap while ensuring optimum overload protection by automatic return to the preselected main shaft position (previous crusher gap). (Author)

1539. Baranov, E.G.; Klochko, I.I. and Oberemok, O.N. "Crushing oversize fragments by means of external charges"; Sov Min Sci 16:1:22-26; 8 ref; 1980

1540. Aleshin, V.I.; Kalinina, G.I.; Reutova, G.V. and Kuznetsov, A.A. "Hammer crushers with screens"; Coke Chem U.S.S.R. 2:55-57; 1979

Commercial trial data are presented on hammer crushers fitted with screens instead of bar gratings. The substitution has improved the size analysis of the crushed product, increased the crusher throughout and reduced the power consumption at the crushing stage. Screens are particularly useful when the moisture content of the coal is excessive. (Authors)

1541. Braun, E. and Braun, G. "Crushing equipment for the comminution of large lump materials, notably coal or like minerals"; U.K. Patent Appl. GB 2 044 634 A; October 22, 1980

Crushing equipment for the comminution of large lump materials, notably for coal or like minerals, which equipment ensures that every lump of such material is brought with certainty under hammers if its size exceeds a maximum limit, comprises a single roll crusher having a crushing roll, hammers mounted on its crushing shaft, and a crushing plate located at a prescribed distance below the hammers and constituted by the deck plate of a pan of a chain conveyor passing through the single crusher, the chain conveyor having a plurality of strands forming a chain matting, the strands being interconnected by carriers and arrayed with classification spacings equal to or smaller than a desired maximum particle size, while they are so positioned relative to the rotary path of the hammers that the latter pass centrally between, and penetrate, adjacent chain strands. (Authors)

1542. Livesay, Richard E. "Impact rock crusher"; U.S. Patent 4,210,292; July 1, 1980

A rock-crushing apparatus is provided with a stationary annular member in which a rock-crushing mechanism is supported. The rock-crushing mechanism has at least two pivoted rock-crushing shanks which are successively impacted by an eccentrically mounted member. The eccentrically mounted member is rotatably driven by a motor and flywheel assembly. The shanks may be biased outwardly so as to trap rocks between the shanks and the stationary member whereupon the successive impacts from the eccentrically mounted member progressively crushes said rocks. (Author)

1543. Motz, J.C. "Crushing flowsheet comparisons in relation to mill feed preparation"; Proc 53rd Annu Meet Minnesota Sect AIME; January, 1980; Duluth, Minnesota; 11:1-11:19

Due to increases in both the need for finer crushing and energy costs, there is a desire for maximum efficiency in crushing and screening operations. Different types of crushers are described for varying feed and product sizes followed by a comparison of different flow designs for maximum efficiency.

ROD AND BALL MILL GRINDING

1544. Opoczky, L. and Mrakovicsne, T.K. "The grinding of cement clinker and the interaction of particles"; World Cem Technol 11:5:245-250; 6 ref; 1980

The particle interaction which occurs during the fine grinding of cement clinker has been studied in laboratory and industrial scale mills.

The Rosin-Rammler-Sperling-Bennet distribution was used to characterize the particle size distribution of the ground products.

It can be stated that the decrease of n, which is a parameter of this distribution, demonstrates the occurrence of particle interaction.

The investigation of the industrial grinding process for ball mills with different loads is set out in the n-diagrams showing the change of the value of n along the mill. (Authors)

1545. Morozov, E.F. "Determination of the rate of crushing of material in drum mills"; Sov Min Sci 16:2:125-132; 10 ref; 1980

The author determines for the kinetic-probabilistic model of particle fracture in a drum mill the probability of particles coming within the zone of impact of the crushing bodies, and the probability of fracture of these particles.

On the basis of several experiments in a laboratory mill with the material being ground, the equation of the crushing rate of the particles permits prediction of the crushing rate of this material under any operating conditions of mills of different sizes.

The introduction of crushing rate equation (24) and batch crushing equation (23), together with use of the functions of the material residence time distribution in the mill, will permit subsequent prediction of the continuous crushing process. (Author)

1546. Slegten, P. and Brisbois, J.M. "Ball-mill grinding on a pilot scale"; Ind Miner Tech 7:389-396; (French); 1980

1547. Vivian, H.E. "A new approach to improve the grinding efficiency of ball mills"; Interceram 29:3:386-388; 1980

A problem which exists in the processing of ores is that of low grinding efficiency in ball mills due to unsatisfactory movement of media and feed within the mill and indirect conversion of power input to useful grinding work This paper studies the movements of both balls and feed and the dissipation of energy within the mill. Improvements to the ball mill are discussed as well as future developments.

1548. Smoyer, Raymond H. "Large ball mills for taconite industry"; Proc 53rd Annu Meet Minnesota Sect AIME; January, 1980; Duluth, Minnesota; 9:1-9:15

1549. Wunderlin, Mark "Energy savings with reduced mill feed size"; Proc 53rd Annu Meet Minnesota Sect AIME; January, 1980; Duluth, Minnesota; 12:1-12:3

1550. Radhakrishnan, V.R. and Sen, P. "Investigation on the noise characteristics of a ball mill"; Indian Chem Eng 22:2:53-55; 1980

1551. Clement, M. and Rieger, K. "Studies on the sieve and grinding circuit for mineral raw materials in a model drum mill in relation to grain size, mill lining, and energy requirement"; EFCE Publ Ser 7:Part. Technol., Vol. A:524-40; (German); 1980

1552. Milosavljevic, R.; Pustric, S. and Salatic, D. "Behavior of size fractions in the industrial grinding and classification processes"; EFCE Publ Ser 7: Part. Technol., Vol.A:450-62; 1980

AUTOGENOUS, SEMI-AUTOGENOUS AND PEBBLE GRINDING

1553. Padokhin, V.A.; Afanas'eva, T.A.; Blinichev, V.N. and Afonin, S.B. "Study of agglomeration during grinding of materials in a vibrational mill"; Izv Vyssh Uchebn Zaved Khim Khim Tekhnol 23:9:1174-6; 8 ref; (Russian); 1980

1554. Yagupov, A.V. and Gegelashvili, M.V. "Dynamic self-comminution ore crushing"; Tsvetn Met 10:107-109; (Russian); October, 1979

1555. Andrews, Norwood Henry "Comminuting and classifying mill"; U.K. Patent Appl. GB 2 045 642 A; November 5, 1980

A comminuting and classifying mill of the re-entrant circulating stream jet type includes a vortex chamber with nozzles for producing a classifying vortex in the chamber. Material is fed in a gaseous carrier from a feed duct tangentially into a feed chamber and hence helically through a recess in one wall of the chamber into the vortex so that the material and carrier gas is added to the vortex with a rotative velocity. (Author)

1556. Loveday, B.K. "Prediction of autogenous milling from pilot-plant tests"; 11th Commonw Min Metall Congr; pp 557-564; 7 ref; 1979

Part of a systematic investigation of scale-up phenomena in autogenous milling is described. Representative samples of the feed to operating plants were tested in a peripheral-discharge pilot mill 1.7 m in diameter and 0.5 m long. Tests on gold ore and carbonatite from Phalaborwa showed that it was possible for the pilot mill to reproduce conditions that obtained in large production mills. It was shown that the density and level of pulp in the mill had a profound effect upon the size distribution of the product and, hence, the mill capacity. This finding has demonstrated the importance of the arrangements for pulp removal in a production mill.

A graphical comparison of pilot-plant performance with full-scale performance has shown that an exponent of 2.5 on diameter is appropriate for scale-up. A method is described for estimating the bulk density of autogenous and semi-autogenous loads, which is used for scale-up calculations. The use of a compression test to measure the resistance to shattering of the pebbles is also described. (Author)

1557. Dogan, Z.M. and Atalay, U. "Suitability of autogenous grinding regarding ore properties"; EFCE Publ Ser 7: Part. Technol., Vol. A: 281-7; 1980

1558. Heinrich, H.E.A. and Supp, A.C "Perimill - A new autogenous mill for coarse grinding"; EFCE Publ Ser 7: Part. Technol., Vol. A: 555-69; (German); 1980

1559. Schelbe, W.; Husemann, K. and Scheer, L. "Studies of the grinding process in impact crushers and pin mills"; EFCE Publ Ser 7:Part. Technol., Vol. A: 49-63; (German); 1980

1560. Marioge, P. "Application of impact grinding to the extractive industry"; EFCE Publ Ser 7: Part. Technol., Vol. A: 436-49; (French); 1980

LINERS AND WEAR

1561. Pinkert, Steffen "Application of wear-resistant steels, e.g. milling media for cement plants"; Giessereitechnik 26:5:135-8; 36 ref; (German); 1980

1562. Dutertre, R.; Geymond, R.; Dours, J. and Crine, R. "Improved performances of mills and of wearing parts"; Ind Miner Tech 3:200-202; (French); 1980

GRINDING MEDIA

1563. Maksudkhodzhaeva, M.S.; Ismailov, A.Kh. and Vidrik, G.A. "Intensification of the grinding process by means of surfactants"; Silikattechnik 31:9:261-2; 7 ref; (German); 1980

1564. Sakaguchi, Masato; Yokono, T.; Sanada, Y.; Shoma, J. and Kashiwabara, H. "Copolymerization of methylmethacrylate on a ball-milled surface of coal at 77K"; Fuel 60:2:136-138; 13 ref; 1981

The ball-milling of coal with methylmethacrylate monomer was carried out under vacuum at 77K and at room temperature and in air. The e.s.r. and i.r. spectra of ball-milled material showed that a copolymer of coal and methylmethacrylate was formed on the surfaces of coal created by ball-mining. Oxygen is an inhibitor to this process. (Authors)

CLASSIFICATION

1565. Bhattacharyya, P. "Theoretical study of the flow field inside a hydrocyclone with vortex finder diameter greater than that of apex opening-I. Laminar case"; Appl Sci Res 36:3:197-212; 15 ref; 1980

The axi-symetric laminar boundary layers, formed on the conical surface and under the cyclone roof, have been calculated by Pohlhausen's method assuming that the tangential velocity outside boundary layer varies as r^{-n} up to the point where boundary layers meet solid body rotating liquid column and thereafter as r - as found in experiments - where r is the distance from

the axis of the cone and n is flow pattern constant. Point of interaction of the boundary layers with solid body rotating liquid column has been taken from experimental results obtained with a hydrocyclone having vortex finder diameter greater than that of apex opening. Results show that there is no possibility of separation of boundary layers from cyclone wall. (Author)

1566. Bhattacharyya, P. "Theoretical study of the flow field inside a hydrocyclone with vortex finder diameter greater than that of apex opening - II. Turbulent case"; Appl Sci Res 36:3:213-225; 10 ref; 1980

As in the laminar case (see previous paper), the axisymmetric turbulent boundary layers have been studied inside a hydrocyclone having overflow diameter greater than that of underflow. This type of hydrocyclone is generally used in practical applications. Calculating total flux through the boundary layers, formed on the conical surface and under the roof of the hydrocyclone, a mathematical model of the flow field has been obtained which agrees very well with previous experimental findings. (Author)

1567. Schaap, W. "Effects of mineral grain size and ore hardness on mill-dump cutoff grades"; Inst Min Metall Trans Sect A 90:A 27-33; January, 1981

In low-grade open-pits, the cutoff grades of disseminated minerals should depend on the age of the mine and on capacity constraints of mine, concentrator or smelter (or concentrate sales contracts). Even for a given plant, however, concentrator capacity is not constant, but is, within limits, a control variable, the value of which is to be decided, if possible, together with the cutoff grade. Concentrator capacity and recovery depend particularly on ore hardness and mineral grain size, which, therefore, in turn affect the mill-dump cutoff grade. After allowance has been made for these operational factors in general terms, a specific example is worked as an example. Optimal cutoff grades are seen to differ markedly from Lane's cutoff grades when ore hardness and effective mineral grain size vary. (Author)

1568. Draeger, Ernest A. and Collins, James W. "Efficient use of water only cyclones"; Min Eng (NY) 32:8:1215-1217; 1980

1569. Schmidt, P. "Air jet screening"; Aufbereit Tech 21:7:337-345; 10 ref; 1980

Applying air jets in fine screening can considerably increase both screening efficiency and accuracy as compared to mechanical screening. The air jets can function as air jet cleaners imply to blow free plugged openings or they can take over the entire process as air jet screening.

In designing continuously operating air jet screens a series of measures must be taken in order to guarantee that the capacity of laboratory screens is also reached on the technical scale. Most important are the conditions for the pneumatic transport of the undersize through the screen, these are air velocity and material load, minimum pressure or impulse of the nozzle air which is needed to whirl-up the material on the screen, nozzle flow-through frequency which hinders plugging, and transport of the oversize over the screen.

Short circuit currents in the screening chamber cause great difficulties. In the threshold case of turbulent mixing a stirring chamber character exists with high false particle content in the oversize. The goal is to achieve stirring chamber cascade character with good separation of the fine material in several whirling-up zones. Because of these difficulties one is often content with a combination of mechanical screening and air jet cleaning or air jet cleaning resp. (Author)

1570. Mallaghan, Michael Lee "Screening apparatus"; U.K. Patent Appl. GB 2 050 869 A; January 14, 1981

Screening apparatus comprises an upwardly-inclined conveyor with a hopper and screen box mounted respectively at the lower end and the upper end thereof. Discrete material fed into said hopper is passed onto the conveyor to be carried up to the screen box for separation by screens into finer and coarser fractions. Fractions greater than a particular size can be removed from the discrete material by an inclined grezzly bar screen mounted over the hopper mouth. The spacings of the bars of said bar screen cannot practically be reduced beyond a predetermined limit, otherwise clogging occurs. To remove oversize fractions passed through the hopper, but not required for grading, a downwardly inclined screen is mounted between the hopper outlet and a feed boot at the loading end of the conveyor with the lower end portion of the screen extending beyond the feed boot so that fractions too

coarse to pass through the screen are deposited clear to the lower end of the conveyor. (Author)

1571. Batterham, R.J.; Weller, K.R.; Norgate, T.E. and Birkett, C.J. "Screen performance and modelling with special reference to iron-ore crushing plants"; EFCE Publ Ser 7: Part. Technol., Vol. B:842-57; 1980

1572. Trawinski, H.F. "Practical application of theoretically ascertained sizing efficiency: Speculative forecast on the ranging of particle sizes in sizing equipment"; Aufbereit Tech 21:9:457-462; 8 ref; (German); 1980

The very early stage of project design work for ore and mineral dressing plants, i.e. prior to running a pilot plant, has to rely on experience and speculation as regards reduction and separating success of the different process operations. The project team head requires for each apparatus information on the anticipated liberation degree (comminution), degree of concentration(cleaning effect) and size distribution (classifying effect). The supplier is asked to submit estimated data. He will be capable of doing so only if he has collected empirical values from operating plants, pilot facilities and test laboratories. This paper deals, in particular, with the shifting of product granulometry (coarse and fine fraction) as compared to the size distribution of the feed. The extent of 'spreading' between coarse and fine fractions can vary considerably at identical sizing efficiency. In the event of one of the two size distributions having been fixed by maximum project requirements, the second one can be calculated by determining the cut point and , consequently, the sizing efficiency. The equipment supplier will then have to determine the skeleton parameters (such as feed solids content, pressure and speed respectively, equipment dimensions). As soon as project team head and supplier have agreed on these values, the attainable particle size ranging will have to be calculated by speculation. Although the granulometric ranging can be numerically determined, it is of little use for a codified system as it is governed by too many factors. Instead, it has turned out appropriate to collect empirical values of the sizing efficiency. The paper presents a system of mathematic formulae which permits calculating product sizes after having fixed cut size and separating efficiency. Preference is given to the internationally applied definition of the sizing efficiency (Taggart). However, it is

likewise possible to use the (standardized) definition applied for pit-coal research work. The paper finally states that the method can also be used for cleaning processes, i.e. for anticipating by speculation concentration and impoverishment, taking it for granted that the mineral components have been strongly liberated. (Author)

1573. Priestly, G. and Stephens, H.S. "Papers presented at an International Conference on Hydrocyclones" Int Conf on Hydrocyclones; October 1-3; 1980; Cambridge, England; 248 pp; 1980

This publication is a collection of papers presented at the International Conference on Hydrocyclones. Papers included within this publication are: "Hydrocyclones with a future" by D.N. Hepburn; "Cyclones as classifiers in ore grinding circuits - A case-study" by S.P. Barber, G.W. Cutting and P.J. Orrock; "A hydrocyclone separation model in consideration of the turbulent multiphase flow" by H. Schubert and T.H. Neesse; "An analysis of boundary-layer effects in a hydrocyclone" by M. Bloor, D.B. Ingham and S.D. Laverack; "Influence of medium viscosity on the density separation of minerals in cyclones" by T.J. Napiermunn; "A new type of hydrocyclone" by T. Larsson; "Sand and mica separation from kaolinite in the United Kingdom china clay industry using 350 mm hydrocyclones" by R.W. Adams; "Hydrocyclone models in an ore grinding context" by A.C. Apling, D. Montaldo and P.A. Young; "Performance of hydrocyclones at high feed solids concentrations" by L. Svarovsky and B.S. Marasinghe; "The application of hydrocyclones as versatile separators in chemical and mineral industries" by H.F. Trawinski; "Hydrocyclone to give a highly concentrated sample of a lighter dispersed phase" by D.A. Colman and M.T. Thew; and "Determination and use of residence time distributions for 2 hydrocyclones" by M.T. Thew, S.A. Silk and D.A. Colman.

MODELLING, KINETICS AND PROCESS CONTROL

1574. Hodouin, D.; Everell, M.D.; Laguitton, D. and Sirois, L.L. " Computer simulation approach to improve comminution strategies for fine-grained complex sulphide ores from New Brunswick, Canada"; In: Complex Sulphide Ores;edited by Michael J. Jones; London: Inst. Min. Metall; pp 40-48; 28 ref; 1980

A step-by-step review is presented of a case history of the application of computer modelling and simulation to explore possible ways of improving a comminution circuit. The studied concentrator, located in New Brunswick, processes a very fine-grained complex Zn-Pb-Cu sulphide ore in a three-stage grinding circuit composed of a rod-mill and two-ball-mills. The various steps of the proposed procedure are: sampling methodology, raw data adjustment to perform coherent material balance computations, rod- and ball-mill model structures, mill model parameters least-squares estimation, hydrocyclone model identification, units and circuit simulators computer implementation and, finally, simulation applications. Various circuit changes are investigated by simulation. For each hypothetical configuration the effect of the change is measured both in terms of improved grind at constant feed rate and increased feed rate at constant grind. Grind improvement is measured by the percentage of particles finer than 37 μm and the proportion of slimes and coarse particles. (Authors)

1575. Sadler, M.F. and Davis, P.M. "Development of a grinding circuit control system"; Symp on Metall Process Instrum; September 20-21, 1978; Randburg, South Africa; 21pp; 1978

1576. Kimmel, I. and Hinde, A.L. "Applications for microprocessors to grinding mill circuit control"; Symp on Metall Process Instrum;September 20-21, 1978; Randburg, South Africa; 30 pp; 27 ref; 1978

1577. Scott, K.J. "On-line determination of size distribution by sedimentation"; Symp on Metall Process Instrum; September 20-21, 1978; Randburg, South Africa; 32 pp; 17 ref; 1978

1578. Hulbert, D.G. and Moys, M.H. "Aspects in the measurement and control of grinding circuits"; Symp on Metall Process Instrum; September 20-21, 1978; Randburg, South Africa; 42 pp; 7 ref; 1978

1579. Kryukov, A.N.; Lur'e, V.G.; Sheshnev, V.G. and Yakhnovskaya, L.P. "Mathematical simulation of coke comminution"; Coke Chem U.S.S.R. 2:23-29; 4 ref; 1979

Data on the comminution of coke made in the Krivoi Rog and Avdeevka plants are used to verify the proposed mathematical model of the comminution process. Estimates are derived for the effectiveness of preliminary mechanical conditioning for cokes made under various conditions. (Authors)

1580. Heitzmann, P.; Ragot, J.; Humbert, C. and Aubrun, M. "Computer control of a grinding-classifying loop system"; Ind Miner Tech 7:375-387; 10 ref; (French); 1980

1581. Rogers. R.S.C. "Application of the segregated flow concept to the analysis and simulation of continuous ball mills by the mechanistic approach"; Ph.D. Thesis, North Carolina State University Raleigh (U.S.A.); 172 pp.; 1979

Part I of this study is concerned with the development of segregated flow models for the analysis and simulation of continuous ball mills. Residence time distributions for continuous mills are modelled with the finite-stage transport concept originally proposed by Adler and Hovorka (1961) and further developed by Rogers and Gardner (1979). Mechanistic models to describe the breakage phenomenon are based on the time-continuous, size-discretized model given by Reid (1965) with modifications to account for non-linear breakage behaviour. Experimental verification of the applicability of the segregated flow approach is given in the Part II paper with results obtained from the analysis of several full-scale, wet-discharge continuous ball mills. (Author)

1582. Marks, Walter R. "Computer aided torsional analysis assures reliable mill drives"; Proc 53rd Annu Meet Minnesota Sect AIME; edited by Paula J. Sanders; January, 1980; Duluth, Minnesota; 7:1-7:12; 9 ref; 1980

Computer aided torsional analysis of grinding mill drives is related to the mill design process and to mill drive reliability. The equations of rotational motion for the system are presented, after which three solution types are discussed. These concern the determination of natural frequencies and mode shapes, the solution for steady vibration amplitudes resulting

from periodic excitations, and the calculation of transient torsional dynamics, particularly as regards mill starting. The simulation of electric motors and their interaction with the mechanical system is discussed. The methods of relating calculated performance to component life are considered. The experiences in both measuring and calculating the torsional dynamics of a large ball mill with dual synchronous motors are reviewed. Finally, conclusions are drawn on the merits of torsional analysis calculations for enhancing mill drive reliability. Included here is some discussion of present limitations. (Author)

1583. Hinde, A.L. and King, R.P. "Difficulties in the practical implementation of mill control systems"; 11th Commonw Min Metall Congr; Inst Min Metall; pp 585-604; 26 ref; 1979

A study was made of the dynamic behaviour of a gold-ore milling circuit that comprised a rod-mill and two pebble-mills operating in closed circuit. The study yielded insight into and understanding of some of the difficulties that are associated with the practical implementation of automatic control strategies. Many of the problems were concerned with system interactions, non-linearities and instrumentation inadequacies. The problems were identified formally and incorporated in a computer simulation model.

The equation structures for the simulator are outlined together with the results of some simulation studies. The simulation results are shown to be consistent with plant on-stream records. Hence, the simulator appears to provide a useful basis for the establishment of the viability of mill control policies in the presence of random disturbances, uncertain measurements and non-linear responses to control inputs. (Authors)

1584. Kausay, T. "Grain size distribution characteristics of concrete aggregates"; Aggregates Fillers Symp; RILEM; 229-240; 1978

The most important property of concrete aggregates is their grain size distribution, which can be numerically described by the grain size distribution characteristics. Such grain size distribution characteristics are the following: the modulus of ineness, the expected value, the average grain size, the specific surface, the variance and the relative variance.

The effect of the grain size distribution of the aggregate on the properties of concrete can be given as a function of the grain size distribution characteristics. The change of the latter ones is sensitively followed by the change of the properties of concrete.

It can be seen that the grain size distribution characteristics of the concrete aggregate form a uniform system on the basis of their substantial community and they are inter-related through this system. (Author)

1585. Malewski, J. "A contribution to forecasting of jaw and cone crusher efficiency"; Aggregates Fillers Symp; RILEM; 256-268; 9 ref; 1978

A method of forecasting of efficiency and grain size distribution of crusher product for jaw and cone crushers has been presented. Special attention has been laid to the determination of the relation between either capacity or product grain size distribution and discharge setting, jaw throw, crusher opening width and feed grain size distribution. Practical formulae determining this dependance have been derivated. (Author)

1586. Heitzmann, P.; Humbert,C. and Ragot, J. "Modelling and computer control of a ball mill unit"; Automation in Mining, Mineral and Metal Processing; August 18-20, 1980; Montreal, Canada; 349-362; 14 ref; 1980

1587. Herbst, J.A.; Rajamani, K. and Pate, W.T. "Identification of ore hardness disturbances in a grinding circuit using a Kalman filter"; Automation in Mining, Mineral and Metal Processing; August 18-20; 1980; Montreal, Canada; 333-348; 13 ref; 1980

1588. Marchand, J.A.; Hodouin, D. and Everell, M.D. "Residence time distribution and mass transport characteristics of large industrial grinding mills"; Automation in Mining, Mineral and Metal Processing; August 18-20, 1980; Montreal, Canada; 295-302; 14 ref; 1980

1589. Hinde, A.L. and Verardi, F.P. "Studies on the design of centrifugal mill grinding circuits"; Automation in Mining, Mineral and Metal Processing; August 18-20, 1980; Montreal, Canada; 283-294; 12 ref; 1980

1590. Weller, K.R. "Hold-up and residence time characteristics of full-scale grinding circuits"; Automation in Mining, Mineral and Metal Processing; August 18-20, 1980; Montreal, Canada; 303-309; 11ref; 1980

1591. Hodouin, D. McMullen, J. and Everell, M.D. "Mathematical simulation of the operation of a three-stages grinding circuit for a fine grained zinc/lead/copper ore"; EFCE Publ Ser 7:Part. Technol., Vol. A: 686-702; 1980

1592. Andel, A.; Thyn, J.; Pechlak,B. and Duffek, K. "Residence time spectrum and comminution in impact mills"; EFCE Publ Ser 7: Part. Technol., Vol. A: 370-85; (German); 1980

1593. Nepomnyashchii, E.A. "The fundamentals of comminution theory and calculations of kinetic dispersity"; EFCE Publ Ser 7: Part. Technol., Vol. A: 255-64; 1980

1594. Denev, S. "Grinding theory from the point of view of the liberation of minerals"; EFCE Publ Ser 7: Part. Technol., Vol.A:424-35; (French); 1980

1595. Alfano, G. "Relationship between comminution energy calculated from laboratory test data and that determined in industrial plant"; EFCE Publ Ser 7: Part. Technol., Vol. A: 265-80; 1980

APPLICATIONS

1596. Forster, Stephen W. "Process control for aggregate production and use"; Public Roads 44:2:53-61; 5 ref; 1980

1597. Joe, E.G. "Energy consumption in Canadian mills"; Trans Can Inst Min Metall 82:111-115; 1979

The continuing increase in costs for power and fuel are affecting significantly the cost of milling Canadian ores. In order to ascertain the scope and and source of energy consumption in Canadian mills for further energy conservation opportunities, CANMET, in cooperation with the Canadian Mineral Processors, carried out a detailed survey on the metallic mineral processing plants. Sixty-seven mills representing almost 300 million tons of annual capacity participated in the survey. The results indicated that, in general, copper and iron ore mills, representing the bulk of the tonnage, consumed relatively low levels of energy per ton. Nickel-copper, zinc-copper and lead-zinc

ore mills were moderate in energy consumption, and uranium and some copper-lead-zinc mills reported much higher energy consumptions due primarily to the increased heat requirements of the ore pulp. Although plant heating costs varied somewhat with location, it was apparent that the lowest heating costs were achieved by those plants built with proper insulation and energy conservation design. If the cost per million British thermal units is taken as $2.00, the mill energy costs generally ranged from 40¢ to $1.20 per ton. (Author)

1598. Anon. "Sand production increased through custom-designed hydrocyclone system"; Rock Prod 83:7:86-90; 1980

1599. Grbovic, M.; Kosutic, L.; Vasic, V.; Stefanovic, K.; Stupar, S. and Nikolic, ?. "Ore concentration plant Veliki Krivelj-Ore crushing, screening and transportation"; Rud Glas 3:41-50; 6 ref; (Yugoslavian); 1980

The paper outlines the effects of ore natural properties on the selection of technical solutions for ore crushing and screening. Specific care was devoted to the effect of the degree of weathering of the ore on the selection of technical solutions and fineness of crushing end product. Characterisitic details are given from the crushing plant design that were developed specifically for the requirements imposed by the natural properties of Krivelj ore. (Authors)

1600. Cutting, G.W. and Barber, S.P. "Characterization and prediction of mineral release during grinding processes: Application to a lead/zinc ore"; EFCE Publ Ser 7: Part. Technol., Vol. A; 137-42; 1980

NOVEL METHODS

1601. Anon. "Attritor milling hardmetal powders"; Met Powder Rep 34:8:377-378; August, 1979

1602. Schneiderman, Stephen J. "Rotating probability screen"; World Coal 6:8:29-31: 1980

The rotating probability screen (RPS) is a new device for separating fines from wet run-of-mine coal. Current operating experience has shown that the RPS can handle up to 100 tons per hour of 19 to 0 mm (0.75 to 0 inch) raw coal feed and separate out at 4 mm (0.16 inch).

The RPS has been developed by the Coal Preparation Division of the Mining Research and Development Establishment (MRDE) of the National Coal Board. The need for such a device arose out of the increased use of water sprays at the coal face to reduce respirable dust. The water sprays raised the amount of wet run-of-mine coal that entered preparation plants. The problem of screen blinding becomes acute when wet fine separation is attempted on conventional vibrating screens because wet fines do not pass through the meshes as easily as dry fines. The RPS was designed to overcome the problem of mesh blinding and does this by avoiding the use of the fine aperture meshes in the separating process. The RPS also has a feed, collection, and discharge system which is designed to handle high moisture material without clogging or flow interruption. (Author)

1603. Anon. "Screens - New ideas and new machines"; Min Mag 143:4:299-319; 1980

Although many types of screening machines, particularly those handling easily separated materials, have basic design characteristics which have remained unchanged for several decades, many detailed improvements have been incorporated. On vibrating screens these include new vibrating mechanisms, variations in the type of vibration, alternatives to steel-coil spring supports - such as fabric reinforced rubber ("Marsh Mellow") and air or foam filled rubber cushions - and improved engineering and fabrication to allow more powerful, longer and wider units to be built without risk of structural failure. Methods have been developed for handling difficult materials, such as wet, sticky fines.

Many new ideas have appeared in the design of screening surfaces: alternatives to the traditional grizzly bars, punched plates and woven wire cloths are surfaces made from rubber, plastic and profiled rods. The means for changing worn surfaces have been improved. Some of the screening equipment available for new plants or modification projects is described in this review. (Author)

CRUSHING AND GRINDING BIBLIOGRAPHY
APRIL/MAY/JUNE 1981

D.G. Vandenhoff

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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	94:12-22; 1981
COMPENDEX	81:03-06; 1981
METADEX (Metal Abstracts)	81:03-04; 1981
NTIS (National Technical Information Service of the U.S. Dept of Commerce)	81:09-14; 1981
SCIENCE CITATION INDEX	81:08-22; 1981

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	14:4-6; 1981
IMM ABSTRACTS	31:2-3; 1981

References are numbered sequentially and are grouped according to the main topics shown below. Not all topics need to be presented in any one report.

A) Review articles
B) Crushing
C) Rod and ball mill grinding
D) Autogenous, semi-autogenous and pebble grinding
E) Liners and wear
F) Grinding media
G) Classification
H) Modelling, kinetics and process control
I) Fracture
J) Applications
K) Novel methods

The author gratefully acknowledges the cooperation of R.J.C. MacDonald, L.L. Sirois and A.I. Stemerowicz, Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

REVIEW ARTICLES

1604. Massey, J.E. "Crushing and grinding -- a review"; Powtech '79, 6th Int Conf in Powder Technol; March 6-9; Birmingham, England; PL1.1-33; 1979

1605. Lynch, A.J. and Whiten, W.J. "The control of fine particle beneficiation processes"; Proc Int Symp Fine Part Process; edited by P. Somasundaran; February 24-28; Las Vegas, Nevada; 1:895-921; 32 ref; 1980

CRUSHING

1606. Nagy, E. and Freis, D. "Revolving-grate impact crusher and its economic application"; Aufbereit Tech 22:2:79-84; 5 ref; (German); 1981

In a revolving-grate impact crusher a conventional rotor with blow bars rotates in a grate made up of grate bars, acting as grinding path and joining the rotary motion at a relative speed. This guarantees that practically no oversize material will accumulate, i.e. material exceeding the grate gap width. According to the peripheral speed of the rotor, this crusher type enables a significant concentration of chip sizes at a definitely reduced quantity of fines.

A comparison of the revolving-grate impact crusher with conventional impact reducing machinery operated in closed circuit with classifiers reveals that the former is superior in economy, too. This is true not only when producing but one product size but also for two or even more size fractions. (Authors)

1607. Wegner, R.L. "The fundamentals of crusher maintenance"; Pit Quarry 73:4:62-65; 1980

Ideas are given for maintenance to reduce downtime and overall plant costs. These pertain mostly to cone crushers but can also apply to screens, conveyors and other plant equipment. Daily maintenance is required by crushers for which a list of do's and don'ts is given. A table of typical crusher problems with possible causes and comments or corrections is also illustrated.

1608. Anon. "Information for gyratory crushers"; Eng Min J 182:4:120-121; 1981

1609. Anon. "A new approach to tertiary crushing"; Quarry Manage Prod 8:2:95-99; 1981

The Barmac Rotopactor is a type of centrifugal impact machine developed for hard and abrasive materials. Differences from the centrifugal impactor are explained, the main difference being that the ejected material from the rotor breaks on impact with a bed of broken stone lying at a 40 degree angle rather than hitting the typical vertical metallic face. Wear of machine parts is therefore greatly reduced. The machine's capacity is directly related to the power input. This is illustrated in a speed-power relationship curve.

ROD AND BALL MILL GRINDING

1610. Austin, L.G. and Bagga, P. "An analysis of fine dry grinding in ball mills"; Powder Technol 28:1:83-90; 14 ref; 1981

The kinetics of dry grinding of several cement clinkers and two coals were investigated in a laboratory tumbling ball mill. The kinetic process is first-order at first, but the rates of breakage decrease as fines accumulate in the bed. It was demonstrated that the slowing of the breakage rates applies to all sizes in the mill, indicating that the cushioning action of fines affects the whole breakage process, even though mill power remains constant. Tests on cleaning or non-cleaning the balls showed that the major factor was not the build-up of a coating on the balls. Radio-tracing tests showed that the effect was not due to pelletizing of fines into larger particles. The quantitative magnitude of the cushioning action was different for different materials. It is, therefore, postulated that cushioning is affected not only by air trapped in the bed of fine particles but also by the cohesive attraction of fine particles, which is a function of the material. (Authors)

1611. Freiermuth, D. and Kirchner, K. "Distribution of ball energy as a function of the milling parameters in ball mills"; Chem Ing Tech 53:5:384-385; 6 ref; (German); 1981

1612. Karra, V.K. "Simulation of the Bond grindability test"; Can Min Metall Bull 74:827:195-199; 3 ref; 1981

A simplistic algorithm for simulating the rod or ball mill Bond grindability test applied to ores and minerals is presented. A performance comparison between the present algorithm and a previously published algorithm by Kapur, modified in this work for a fair evaluation, is also given. A worked example is furnished for leading the reader through the various calculations. (Author)

1613. Zickar, E.J.; Gillett, F.G.M. and Shore, J.R. "The addition of fines to improve rod mill performance at Frood-Stobie mill"; Can Min J 102:3:41-46; 1981

Frood-Stobie mill is situated within the Frood-Stobie mining complex, on the southern rim of the Sudbury Basin. The mill commenced operations in November 1967, and has since processed in excess of 65 million tons of ore. The crushing plant product, averaging five to eight per cent plus 3/4 in., is the feed to the rod mills. Because of the wet screening method employed, it is void of the naturally occurring primary ore fines. This absence of fines tends to make rod milling somewhat more difficult. (Authors)

1614. Zisselmar, R. "Grindability testing of materials with different physical properties as a basis for the design of grinding plants"; Zem Kalk Gips 34:4:187-196; 26 ref; (German); 1981

Of decisive importance for the dimensioning of grinding plants is the question of the power needed to crush granular material to a certain fineness of the finished product. Due to the lack of appropriate mathematical relations the power demand is calculated experimentally with the aid of laboratory mills. This type of testing equipment, which only partly copes with the actual circumstances in large plants, permits the measurement of material-related grindability test values which, taken as global measures, typify the crushing behaviour of materials under certain stress conditions. The various grindability testing methods which are essential to industrial practice are described and compared with each other with the object of discussing the pros and cons in the selection of an appropriate testing method. A much-discussed selection criterion is the transferability of laboratory values to large plants. For grindability testing of cement clinker

and cement raw materials Zeisel's method is gaining ground. Designing raw mills for clinker grinding on the basis of this method can be carried out very safely, provided that certain marginal conditions are observed. However, in the case materials such as cement raw materials with greatly differing physical properties due to their different geological and geographical origin there is still some uncertainty in the mill layout. To be able to also dimension cement raw material plants on the basis of Zeisel's method as safely as possible, the results of grindability tests on various materials are compared with the results from a great number of plants in operation. This comparison reveals that the correlation between laboratory values and operating data is described very precisely by an exponential function which contains the finished product fineness as a parameter and which is appropriate for the requirements of practical operation. This offers the possibility of dimensioning not only cement clinker grinding plants very reliably but also cement raw material grinding plants on the basis of grindability testing by Zeisel's method in connection with power input calculation (e.g., according to Blanc/Eckardt). (Author)

AUTOGENOUS, SEMI-AUTOGENOUS AND PEBBLE GRINDING

1615. Kaiser, Obering F. and Nied, R. "Modern jet pulverizers"; Aufbereit Tech 21:10:507-514; 10 ref; (German); 1980

In spite of high and still rising energy costs, high energy-consuming jet pulverizing still is and will continue to be the most favourable reduction method for many duties. According to the specific problem, either the well-known spiral-type jet pulverizer or the fluidized-bed jet pulverizer is used. The last mentioned model has recently been significantly improved as to fineness and energy consumption by changing over to the counter-jet principle and by introducing a new classifier. This machine is not subject to any wear in the mill section proper and only to slight wear in the classifier.

The paper explains the operating mechanism of the automatic fineness regulation for the spiral-type jet pulverizer and points out to the very narrow range of optimum energy consumption.

Since the energy consumption of jet pulverizers is strongly dependent on primary crushing of the feed, the paper suggests a new method for correcting this influence so as to enable comparing different pulverizer designs.

All important performance parameters and operating characteristics have been listed in a table for selecting the best suitable equipment for a specific duty.

The information includes data on the historical development of the equipment and its application. (Authors)

1616. Bessarear, John H. "Semi-autogenous vs. conventional steel consumption at Cyprus Pima"; Proc AIME Annu Meet Prepr N 80-57; February 24-28, 1980; Las Vegas, Nevada; 8 pp.; 3 ref; 1980

1617. Talbott, Lyle W. and Hartzog, Laurence D. "Semi-autogenous grinding at the Delamar silver mine"; Proc AIME Annu Meet Prepr N 80-59; February 24-28, 1980; Las Vegas, Nevada; 3 pp.; 1980

1618. Moys, M.H. "The control of autogenous and semi-autogenous mills: the relationship between measurements of bearing pressure and parameters describing the mill load"; J S Afr Inst Min Metall 80:11:401-408; 7 ref; 1980

The capacity of grinding mills can be maximized by use of measurements of mill power and bearing pressures. The criterion is as follows. If the derivatives with respect to time of the power and bearing-pressure signals have the same sign, the volume of the mill load is smaller than the optimum value; if they have different signs, the volume of the mill load is greater than the optimum value. Few attempts have been made to use measurements of bearing pressure in the estimation of absolute values for the parameters that define the state of the mill load (e.g. mass, volume, and dynamic angle of repose) because the bearing-pressure signal is a complex function of these and other parameters. This paper gives a mathematical model that relates bearing pressures to these parameters. The theoretical values obtained from this model are compared with experimental values, and it is concluded that the model constitutes a good description of experimental reality. If accurate measurements of the load supported by each bearing are available, the model can be used in the

estimation of the mass of the load in the mill. If independent estimates of the volume of the load or the dynamic angle of repose are available, the other parameter can be estimated from measurements of the bearing loads. (Author)

LINERS AND WEAR

1619. Coles, H.R. and Chong, S.P. "New liner design improves Aerofall mill throughput"; Proc AIME Annu Meet Prepr N 80-129; February 24-28, 1980; Las Vegas, Nevada; 28 pp.; 2 ref; 1980

1620. Sare, I.R. and Hall, W.B. "The determination of gouging abrasion resistance by jaw crusher tests"; Conf on Lubrication Friction and Wear in Eng, Inst Eng Australia December 1-5; Melbourne, Australia; 80:12:94-98; 1980

1621. Wagner, K.; Faust, H.; Brutschin, F.; Isert, C. and Gaedike, H. "Wear of crushing mills during the production of building materials"; Schmierungstechnik 11:9:275-7; (German); 1980

1622. Korpi, P.A. and Dopson, G.W. "New ball mill lining cuts cost"; Eng Min J 182:2:78-82; 1981

The newly developed angular spiral lining used for wet grinding greatly reduces the use of grinding media and the consumption of energy. The lining changes the mill cross section to a square with rounded corners. The staggered rows and spirals cause the material to spiral towards the feed end of the mill opposite to the mill rotation.

GRINDING MEDIA

1623. Zadak, Z.; Zezulka,J.; Novotny, J.; Kolar, K. and Skvara , F. "Grinding of cement clinker with liquid and powder grinding aids"; EFCE Publ Ser 7:Part. Technol., Vol. A: 327-39; 1980

1624. El-Shall, Hassan El Sayed "Effect of chemical additives on grinding"; Dissertation Order no. 8028782, Columbia University (New York); 312 pp.; 1980

1625. Klimpel, R. and Samuels, R. "Chemical additives for improving the wet grinding of ores"; Proc 11th Annu Meet Can Miner Processors 290-318; 1979

CLASSIFICATION

1626. Vincent, J.C. "Preconcentration of mill feeds using automated ore sorting processes"; S Afr Min Eng J 92:4172:34-51; 12 ref; 1981

Ore sorting is a high capacity, low cost method of preconcentrating ores and in some cases, of producing a marketable concentrate. In most cases it is applied to run of mine material immediately after primary crushing and screening in sizes ranging from 10 mm to 150 mm. (Author)

1627. Dreissen, H. and Absil, J.H. "Theory, practice and development of the DSM heavy media cyclone process for minerals"; Proc AIME Annu Meet Prepr N 80-11; February 24-28, 1980; Las Vegas, Nevada; 10pp.; 6 ref; 1980

1628. Nichols, J.P. "Wider vibrating screens/Bigger is better"; ASME Mater Handling Conf, Century 2 - Emerging Technol Conf; August 19-21; San Francisco, California; 113-115; 1980

1629. Chander, S. and Sharma, V.N. "Characterization of fine particles in complex ore processing"; Proc Int Symp Fine Part Process; February 24-28; Las Vegas, Nevada; 1:525-543; 21 ref; 1980

1630. Diaz, L.S. "Continuous particle-size measurement - A status report"; 8th Ann Mining and Metallurgy Div Symp of the Instrument Soc of Am; edited by E.F. Kurzinski; May 14-16; Phoenix, Arizona; 7:111-124; 1980

1631. Brust, Gil "Vibrated sieves solve "fines" problem at prep plant"; Coal Min Process 17:9:75-81; 1980

1632. Ternovskii, I.G. and Kutepov, A.M. "Hydrocyclones: Design, computation methods, and application"; Khim Neft Mashinostr 12:9-11; (Russian); 1980

1633. Korotaeva, I. Ya.; Drokov, V.G.; Durnova, L.G. and Issers, V.V. "Study of the grinding of quartz-sulfide ores and gold contained in them"; Deposited Doc VINITI 2419: 8 pp.; (Russian); 1979

1634. Heiskanen, K. "Improved grinding circuit performance by two-stage classification"; EFCE Publ Ser 7:Part. Technol., Vol. B: 826-41; 1980

1635. Griksson, O. "Suggestions for advanced calculation methods for determining required screen surface"; Aufbereit Tech 22:2:85-95; 5 ref; (German); 1981

1636. Sommer, K. "Sampling errors occuring during particle size analyses"; Aufbereit Tech 22:2:96-105; 5 ref; (German); 1981

MODELLING, KINETICS AND PROCESS CONTROL

1637. Gupta, V.K.; Hodouin, D.; Berube, M.A. and Everell, M.D. "The estimation of rate and breakage distribution parameters from batch grinding data for a complex pyritic ore using a back-calculation method"; Powder Technol 28:1:97-106; 38 ref; 1981

Using the batch-calculation approach, simultaneous estimation of rate and breakage distribution parameters has been carried out for a complex pyritic ore from the batch ball mill size distribution data. The ore showed several deviations from the normal grinding behaviour: (i) the slope of the Gaudin-Schumann plots in the fine size range varied with the feed size and the grinding time, (ii) the first-order plots showed marked curvature in the initial period of grinding, (iii) the rate parameters did not conform to the relationship $S_i=Ax_i^{\alpha}$, even in the fine size range, and (iv) the breakage distribution parameters exhibited a high degree of non-normalizability. The main problem encountered was the choice of a suitable functional form for the breakage distribution function. This paper illustrates the limitations of the two existing functional forms and several other functional forms used in this work, and emphasizes the need for having a more general and practical functional form for the breakage distributions function. (Authors)

1638. Zanker, A. "Quick calculation of circulating load and classifier efficiency in open grinding circuits"; Mining Congress J 67:5:57-58; 1981

1639. Zawada, Jan "Determination of crushing forces with allowance for elasticity theory"; Przegl Mech 39:12: 20-22; 5 ref; (Polish); 1980

1640. Petty, A.V. and Nevin, D.B. "Computer program to aid in particle-size distribution"; Am Ceram Soc Bull 60:4:506-507; 1981

1641. Heidenreich, E. and Kloden, W. "Interpretation of particle-size analysis results using computers"; Chemische Tech 33:3:130-134; 8 ref; (German); 1981

1642. Olsen Thor O and Lenhartzen, Thore "Identification of a grinding circuit from experimental data"; Can Conf on Autom Control ; May 23-25; Montreal, Quebec; 5.3: 8 pp.; 4 ref; 1979

1643. Klimpel, Richard R. "Engineering analysis of dispersion effects in selected mineral processing operations"; Proc Int Symp Fine Part Process; February 24-28; Las Vegas, Nevada; 2:1129-1152; 34 ref; 1980

1644. Taushkanov, G.P. "External characteristics of cyclones"; Zh Prikl Khim (Leningrad) 53:11:2580-3; (Russian); 1980

1645. Kuznetsov, A.A.; Kutepov, A.M. and Ternovskii, I.G. "Turbulence in a hydrocyclone"; Izv Vyssh Uchebn Zaved Khim Khim Tekhnol 23:11:1442-5; (Russian); 1980

1646. Hilger, M.; Hetthessy, J.; Keviczky, L. and Kolostori, J. "Comparative investigations on the control of closed-circuit ball mills on the basis of operating results"; Zem Kalk Gips 34:3:146-150; 9 ref; (German); 1981

Simple and complicated control systems for material flow rate control of cement grinding mills operating in closed circuit are described and critically reviewed. Besides, newly developed control systems geared to maximizing the product output are explained and the experience gained with them is reported. The results of tests performed, and the control algorithm tested by simulation, are described and discussed. (Authors)

1647. Finch, J.A. and Ramirez-Castro, J. "Modelling mineral size reduction in the closed-circuit ball mill at the Pine Point Mines concentrator"; Int J Miner Process 8:1:61-78; 21 ref; 1981

Using plug flow material transport and a cumulative-basis rate-of-breakage parameter, overall size reduction through the closed-circuit ball mills at the Pine Point and Gibraltar concentrators was simulated over a wide range of operating conditions. The rate-of-breakage parameter was related to particle size by a power law, the exponent (n) being: Pine Point, $n=1.043 \pm 0.026$, and Gibraltar, $n=0.747 \pm 0.020$. The success of this approach probably stems from the high (>1.5) circulating load ratios encountered.

By analogy individual mineral size reduction at Pine Point was examined. A similar rate-of-breakage parameter versus size relationship was found. Pyrite was the hardest mineral, but fine galena was equally resistant. However, the approximation that mineral and overall rates of breakage were the same gave an adequate fit to the mineral size reduction. This was emphasized by combining with a cyclone model to simulate cyclone overflow mineral size distribution. A more accurate cyclone model is shown to be more important in simulating mineral deportment at Pine Point.

Complementary laboratory batch grinding tests were conducted on rod mill discharge and ball mill feed samples. Sufficient agreement with the first-order hypothesis was observed to analyse the rate-of-breakage parameter. The kinetics was similar for both samples and in turn similar to the plant-derived kinetics in terms of relative mineral rates-of-breakage and the relationship of the rate-of-breakage parameter with particle size. (Authors)

1648. Songren, Li et al "The mathematical model of a steady state grinding circuit and its simulation using a computer"; J Cent South Inst Min Metall, China 4:45-52; 2 ref; (Chinese); 1980

FRACTURE

1649. Harrington, T.P.; Doctor, O.G.; Hartley, J.N. and Prisbrey, K.A. "Acoustic analysis of primary breakage fragment distributions in mineral grinding"; Proc AIME Annu Meet Prepr N 80-132; February 24-28, 1980; Las Vegas, Nevada; 25 pp.; 5 ref; 1980

APPLICATIONS

1650. Eddingfield, D.L. and Trinh, V.D. "Preliminary study of coal comminution with a high velocity water jet"; Proc 5th Int Symp on Jet Cutting Technol; June 2-4; Hanover, Germany; 251-258; 1980

1651. Trass, O. and Papachristodoulou, G. "Grinding of coal-in-oil slurries with the Szego mill"; 2nd Int Symp on Coal-Oil Mixture Combust; November 27-29; Danvers, Massachusetts; 2:28 pp.; 1979

1652. Klovers, E.J. "Capability of roller mills to handle soft and high moisture materials"; 22nd IEEE Cement Ind Tech Conf May 19-22; Toronto, Ontario; 149-168; 1980

1653. Jordan, C.E.; Sullivan, G.V. and Davis, B.E. "Pneumatic concentration of mica"; Bureau of Mines PB 81-150005 (BUMINES - RI - 8457); 31 pp.; 1980

1654. Steensma, R.S. "The Hudson jig and pulverizer"; 1st Int Conf on the Future of Small Scale Mining; edited by R.F. Meyer and J.S. Carman; November 26- December 5, 1978; Jurica, Mexico; 349-351; 1980

1655. Dungan, E.W. "Exposure with a coal pulverizing system at Arizona Portland Cement Company"; 8th Annu Mining and Metallurgy Div Symp of Instrument Soc of Am; edited by E.F. Kurzinski; May 14-16; Phoenix, Arizona; 7:51-53; 1980

1656. Iordacheseu, G. R. and Pop, A. "Effect of critical size grains on productivity of cascade grinding mills"; Mine Pet Gaze 31:5:228-233; (Romanian); 1980

1657. Cleemann, J.O. "Ways to control particle size distribution for ground products"; EFCE Publ Ser 7:Part. Technol., Vol. A: 23-48; 1980

1658. Paukar, V.I.; Zubarev, V.I.; Lifirenko, V.I.; Kitsnik, A.A. and Akhelik, V.R. "Concentration of bauxites using centrifugal reflecting mills"; Tsvetn Met 2:101-3; 3 ref; (Russian); 1981

1659. Cotea, Ion; Puscasu, Doru and Moraras, Constantin "Energy consumption reduction in the cement industry. Part I. Raw material crushing and grinding"; Mater Constr (Bucharest) 10:2:59-62; (Romanian); 1980

1660. Ellerbrock, H.G. "Energy balances in cement mills"; EFCE Publ Ser 7:Part. Technol., Vol. A: 463-76; (German); 1980

1661. Dikinov, G.K. ; Naryshkin, A.P.; Savin, V.F.; Dikinova, N.S. and Ustinov, I.D. "Improvement in the technology of ore dressing at the Tyrny-Auz concentrating mill"; Tsvetn Met 2:109-12; (Russian); 1981

1662. Bubnovskaya, L.M.; Popov, V.K. and Rus'yanova, N.D. "Effect of crushing coal on its IR spectrum"; Coke Chem (USSR) 1:6-9; 6 ref; 1980

Methods of preparing coal specimans to record the full compound broken internal reflectance (FCBIR) spectra are compared. The results are discussed. (Authors)

1663. Pabst, Marilyn "Thompson mill concentrates 12,000 tpd"; Can Min J 101:11:48-51; 1980

The Thompson mill has undergone an expansion from its original capacity of 6000 tpd to its present size of almost 12,000 tpd. Feed for the mill comes half from the Thompson mine and half from the Pipe open pit. Ore from each mine is concentrated in separate circuits. (Author)

NOVEL METHODS

1664. Khopunov, E.A.; Shatailov, Yu. L. and Voronchikhin, S.L. "Weakening of ores in the Synder process"; Sov Min Sci 15:6:581-586; 7 ref; 1979

Crushing methods based on utilization of the energy of a high-pressure gas show promise in respect of action on ore, because they best satisfy the conditions of selective separation of the ores and rational ore preparation.

Investigations of one version of these methods, namely the Synder process, have confirmed that it gives a higher degree of separation of minerals than the usual methods of crushing (with balls or jets). (Authors)

1665. Marioge, P. "Projection grinding"; Ind Miner (S Etienne Fr) Tech 2:127-134; 11 ref; (French); February, 1981

CRUSHING AND GRINDING BIBLIOGRAPHY
JULY/AUGUST/SEPTEMBER 1981

D.G. Vandenhoff

February 1983

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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	94:24-26; 1981 95:02-10; 1981
COMPENDEX	81:07-09; 1981
METADEX (Metal Abstracts)	81:05-09; 1981
NTIS (National Technical Information Service of the U.S. Dept of Commerce)	81:15-21; 1981
SCIENCE CITATION INDEX	81:23-33; 1981

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	14:7-9; 1981
IMM ABSTRACTS	31:4; 1981

References are numbered sequentially and are grouped according to the main topics shown below. Not all topics need to be presented in any one report.

A) Review articles
B) Crushing
C) Rod and ball mill grinding
D) Autogenous, semi-autogenous and pebble grinding
E) Liners and wear
F) Grinding media
G) Classification
H) Modelling, kinetics and process control
I) Fracture
J) Applications
K) Novel methods

The author gratefully acknowledges the cooperation of R.J.C. MacDonald, L.L. Sirois and A.I. Stemerowicz, Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada.

REVIEW ARTICLES

1666. Holt, C.B. "The shape of the particles produced by comminution. A review"; Powder Technol 28:1:59-63; 16 ref; 1981

In this paper the literature on the shape of particles produced by comminution is reviewed. There is some agreement amongst workers as to the shapes which are produced by comminution machinery. However, the subject does not have a sound scientific foundation and authors disagree as to the importance of different factors. This ought to be remedied in view of the growing realisation of the importance of particle shape in controlling powder behaviour. (Author)

1667. Dolezil, M. and Reznicek, J. "Mineral processing -- 1979: Tenth anniversary report"; World Min 33:8: 54-67; 181 ref; 1980

1668. Anon. "Focus on mills, grinders and crushers"; PACE Process Chem Eng 34:2:32-34; 1981

CRUSHING

1669. Forsthoff, W. "Effect of drilling and blasting upon the performance and cost of subsequent operations in limestone quarries"; Zem Kalk Gips 34:1:11-19; 4 ref; (German); 1981

Loading performance and cost are largely determined by the properties of the rock pile dislodged by blasting. The lower its resistance to penetration by the loading bucket, the less time it takes to perform a loading cycle and the better is the bucket filling capacity. As a result, loading performance is improved, while the cost is correspondingly reduced. Furthermore, the working conditions for the loading machine are less severe, so that excessive increase in maintenance and repair costs is avoided. There is moreover an indirect effect on haulage costs, as the waiting time of the trucks at the loading point depends on the loading performance attained. Where the material is quarried below the level of installation of the crusher, the distances between the successive quarry floors affect the haulage costs. The shorter these distances are chosen, the less will be the time and energy consumed in raising the quarried rock to crusher level. Close quarry floor spacings moreover make it possible to

apply electric detonation of the explosive charges from the bottom of the holes, a method which achieves a very high degree of utilization of the energy content of the explosive. The fragmentation of the rock pile has an effect on the throughput of the primary crushing stage and thus often on the throughput of the preparation process as a whole. Besides, it is of major effect on the cost of secondary fragmentation. It is attempted, in this article, to establish a relationship between the chosen drilling and blasting method and the subsequent operations of loading, secondary fragmentation, haulage and primary crushing. It emerges that a methodically applied increase in expenditure on drilling and blasting can bring about an increase in performance and a lowering of cost throughout all stages of quarrying and raw material preparation. Since the limestone quarried for the lime industry is used mainly for lime burning, the needs and interests of the burning and further processing plants have to be duly taken into account in connection with all the quarrying activities. The intensive quality control that this necessitates, for example, may impose restrictions on the choice of methods and machinery that can be considered suitable for the purpose. (Author)

ROD AND BALL MILL GRINDING

1670. Austin, L.G.; Bagga, P. and Celik, M. "Breakage properties of some materials in a laboratory ball mill"; Powder Technol 28:2:235-243; 21 ref; 1981

Crystalline quartz, silicon carbide, three coals of different rank and a cement clinker were studied in a small laboratory ball mill under standard conditions. The first-order specific rates of breakage and the cumulative primary daughter fragment distributions were determined. Two coals showed a slowing down of breakage rate at fine dry grinds. Anthracite showed an acceleration of grinding rate. Wet grinding was first order in all cases even to very fine grinds. Wet grinding was always faster than dry grinding for a given material but the shapes of the size distributions were the same within experimental variability. (Authors)

1671. Anon. "Ball milling techniques. January, 1970-March, 1981 (Citations from the Engineering Index Data Base)"; U.S. NTIS Rep PB81-863 854: 120 pp.; March, 1981

1672. Swaroop, S.H.R.; Abouzeid, A.Z.M. and Fuerstenau, D.W. "Flow of particulate solids through tumbling mills"; Powder Technol 28:2:253-60; 15 ref; 1981

The transport behaviour of particulate solids flowing through tumbling mills depends strongly on the mill operating conditions. This paper presents the results of a detailed study to delineate the effect of the important operating variables on the hold-up, mean residence time and residence time distribution of particulate solids flowing through ball mills and rod mills. The effects of feed rate, media load, and mill speed on these transport parameters are discussed, emphasizing the fundamental differences between particulate transport in ball mills and rod mills. Under identical dimensionless operating conditions over the range of the investigation, the material hold-up and the Peclet number of the flow regime in the rod mill were always higher than those in the ball mill. Mechanistic interpretations of the observed transport phenomena are presented, and their implications in the context of tumbling mill analysis and design pointed out. (Authors)

AUTOGENOUS, SEMI-AUTOGENOUS AND PEBBLE GRINDING

1673. Hansen, J.P.; David, E.G. and Sullivan, G.V. "Autogenous attrition microgrinding of calcium carbonate minerals"; U.S. Bureau of Mines Rep PB81-179 962: 22 pp.; 1980

1674. Karmazin, V.I. "Technology for beneficiating carbonate ores from the Bol'shoi Tokmak deposit"; Obogashch Polezn Iskop 26:50-5; (Russian); 1980

LINERS AND WEAR

1675. Anon. (to Acieries Thome-Cromback, Fr.) "Steel for use in making grinding apparatus"; Belg. Patent 881 593; 12 pp.; (French); August 7, 1980

1676. Shelud'ko, G.P.; Blokh, G.A.; Sokolov, V.I.; Chekreneva, L.S.; Pirotskii, V.Z. and Sidorovskii, E.L. "Rubber mixture for ball mill lining"; U.SS.R. Patent 806 705; (Russian); February 23, 1981

1677. Crisi, J.S. "Selecting balls and liners for grinding mills"; Chem Eng (NY) 88:18:127-129; 1981

There are two main types of liners for grinding mills - lifters and classifiers. For each different shape of lifter liner described, the mechanism of action is explained. Several materials are suggested for liners and balls; and finally, price-to-life and price-to-consumption comparisons are made for liners and balls.

CLASSIFICATION

1678. Beeckmans, J.M. "The inclined plane particle classifier"; Powder Technol 28:2:129-134; 2 ref; 1981

A novel pneumatic particle classifier, termed the inclined plane classifier (IPC), is described. The performance of the IPC was determined for a variety of operating conditions, using limestone particles in the size range 0.1 - 1.0 mm. Reasonably sharp separations were obtained, and it was found possible to correlate the observed cut sizes by numerically solving the particle trajectory equations for the flow field and boundary conditions appropriate to each experiment. ~~(The IPC appears to be a useful alternative to each experiment.)~~ The IPC appears to be a useful alternative to screening for dry classification, which avoids some of the difficulties encountered in industrial dry screening of particles below 1 mm in size. (Author)

1679. Anon. "Screens convert fines into profits"; Coal Age 86:2:121-122; 1981

The screen described is an adaptation of the Mogensen sizer, normally used for grain, gravel, and sugar, to the screening of wet anthracite. The screen is compact, lightweight, and designed for high throughputs. The new feature of the sizer is the increasing pitch of the angle of each successive screen that the material comes into contact with. This patented feature is described in detail in this article.

1680. Wang, James C.F. and Tichenor, Daniel A. "Particle size measurements using an optical variable frequency grid technique"; Appl Opt 20:8:1367-1373; 10 ref; 1981

A fringe visibility method for sizing particles 10 microns and larger has been developed. As the image of a particle scans across a variable frequency grid, the transmitted light signal oscillates with varying visibility. The visibility goes through a null at a well-defined point where the particle diameter approximates the local grid spacing. Several optical arrangements implementing the variable frequency grid technique have been tested. Using classified alumina and pulverized coal particles, the authors obtained good agreement between size distributions measured by this technique and those from a commercial off-line analyzer. However, the optical arrangement and signal processing techniques require further development to reduce them to practice. (Authors)

1681. Kutepov, A.M.; Ternovskii, I.G. and Kuznetsov, A.A. "Hydrodynamics of hydrocyclones"; J Appl Chem USSR 53:12:2019-2024; 9 ref; 1980

In order to calculate the separation characteristics of hydrocyclones, it is important to be able to specify the tangential velocity with precision. The electrodiffusion method was used to determine the tangential velocity profile in this case. The parameters tested for influence on this profile include: the cyclone diameter, cone angle, height of the cylinder, pipe diameters, the immersion depth of the discharge pipe and the feed pressure. It was found that there are two distinct regions in the tangential velocity profile. Conditions are presented for each of these regions.

1682. Muly, E.C. and Frock, H.N. "Industrial particle size measurement using light scattering"; Opt Eng 19:6:861-869; 13 ref; 1980

1683. Shifrin, S.I.; Galka, B.A.; Keitel'gisser, I.N.; Zhuravel, V.A.; Nosov, R.E. and Nelepov, V.F. "Hydrocyclones to remove sludge from coal fines"; Coke Chem USSR 4:10-12; 2 ref; 1980

The article examines results of industrial tests of the operation of hydrocyclones to remove sludge from coal fines before cleaning in jigging machines. The relationship of the technological efficiency of the sludge removal process and the diameter of the sand bed of the hydrocyclone is shown. (Authors)

1684. Ryskin, M.Ya. "Hydrocyclones in pyrite concentrate production"; Tsvetn Met Nauchno Tekh Sb 5:1-15:17-19; (Russian); March, 1980

1685. Prem, H. and Prior, M.H. "Some recent developments in size reduction and air classification"; 1981 Powtech Conf, Inst Chem Eng; March 10-13; Birmingham, England; 63:1-19; 1981

1686. Fehr, Manfred and Cloutier, Leonce "Scale-up criteria for hydrocyclones"; Rev Bras Technol 11:4:279-288; 17 ref; (Portuguese); 1980

1687. Pecanha, Ricardo Pires and Massarani, Giulio "Assessment of hydrocyclone performance"; Rev Bras Technol 11:4:289-299; 13 ref; (Portuguese); 1980

1688. Mokrousov, V.A.; Litvintsev, E.G. and Gulin, E.N. Preliminary radiometric beneficiation stabilizes ore quality"; Tsvetn Met 3:98-100; 9 ref; (Russian); 1981

1689. Anon. "Screens and sieves used in industrial processes. January, 1970 - May, 1981 (Citations from the Engineering Index Data Base)"; U.S. NTIS Rep PB81 - 866 709: 179 pp.; May, 1981

1690. Qiren, C. and Jiazhi, X. "Centrifugal separator for beneficiation of wolframite slimes"; Nonferrous Met (China) 32:4:33-35; (Chinese); 1980

1691. Rogers, R.S.C. "Coal materials handling: classifier evaluation. Quarterly Progress Report, October-December, 1980"; U.S. Dept of Energy Rep DOE/ MC/ 14266 - T3: 177 pp.; 1980

MODELLING, KINETICS AND PROCESS CONTROL

1692. Kovalyukh, V.R. and Gud, M.B. "Mathematical model of a ball mill"; Sov Min Sci 16:4:373-375; 2 ref; 1980

A mathematical model for use in the design of an automatic control system for a crushing plant is formulated for a ball mill. Control action occurs at the input to the mill while the output variable is the noise of the mill. This variable is correlated with the fineness of the grind, a quantity which is difficult to measure for control purposes.

1693. Kapur, P.C.; Sastry, K.V.S. and Fuerstenau, D.W. "Mathematical models of open circuit balling or granulating devices"; Ind Eng Chem Process Des Dev 20:3: 519-524; 19 ref; 1981

1694. Ribier, R.; Takata, A.L. and Anderson, A. "Automatic grind control at Arafertil phosphate mill"; World Min 34:4:53-59; April, 1981

Analog control methods, an Armco Autometrics particle size analyzer, and a practical approach to keeping the system simple were the key in achieving the design goals of the Brazilian concentrator's automatic control. (Authors)

1695. Aleksandrovskii, A.A.; Galiakberov, Z.K.; Emikh, L.A.; Trifonova, N.P. and Bobrov, G.S. "Kinetics of the mixing of a binary composition in the accompanying solid-phase grinding"; Teor Osn Khim Tekhnol 15:2: 227-31; (Russian); 1981

1696. Austin, L.G.; Vanorden, D.; McWilliams, B.; Perez, J.W. and Shoji, K. "Breakage parameters of some materials in smooth roll crushers"; Powder Technol 28:2:245-251; 5 ref; 1981

A model has been developed to describe the size distributions produced by fracture of material in a smooth roll crusher. The model assumes that each size breaks independently of other sizes, that the breakage pattern depends on the relative size of particle to gap, and that the overall breakage pattern can be deduced from repeated fracture with a normalized primary breakage distribution and bypass of sizes through the gap without breakage. The descriptive parameters of primary breakage distribution and bypass are given for two rocks and eight coals. (Authors)

1697. Beke, B. "Efficiency of grinding: present status and outlook"; Aufbereit Tech 21:10:521-524; (German); 1980

The term "efficiency of grinding" is interpreted differently in expert literature: the energy consumption is referred to surface energy, to the energy required for fracture propagation, to the development of heat as lost energy or to the energy required for ideal individual grain reduction.

For a large-scale assessment of the problem only the last-mentioned factor should be considered. This results in the conclusion that the presently most

widely applied ball mills operate most uneconomically as compared with roll mills. Good energy utilization is anticipated for compression reduction and for surface attrition. (Author)

1698. Molerus, O. "Axial mixing during transport processes in continuously operating apparatus"; Chem Ing Tech 38:22 pp.; 1966

1699. Hodouin,D.; Berube, M.A. and Everell, M.D. "A study of the parameters of the mathematical models used to simulate the milling process"; Ind Miner Mineral (Supplement) 28 pp.; February, 1979

1700. Shvidenko, A.A.; Fedorov, V.G.; Okolovich, A.M.; Bichevina, N.G. and Alkanov, E.A. "Control of the coarseness of ore grinding by monitoring the amount of flotation circulating products"; Izv Vyssh Uchebn Zaved Tsvetn Metall 2:108-12; (Russian); 1981

APPLICATIONS

1701. Schneider, L.T.; Blasczyk, G. and Lohnherr, L. "Operational experience with modern coal grinding plants - ball and roller mills"; Zem Kalk Gips 34:5:260-267; 6 ref; (German); 1981

Six coal grinding/drying plants commissioned in 1980/1981 are presented. Three of these are equipped with ball mills and three with roller mills. The respective types of mill are described, and the lay-outs of the plants and the performance figures attained by them are reported. A particular problem is considered with reference to each individual plant, namely: fault condition due to explosion; path of the raw coal; speed control of a ball mill; starting and stopping a coal grinding plant; insulation, heating of pulverized coal bins; relationship between oxygen content and dew-point. (Authors)

1702. Sibbald, C.V. "The Highmont Concentrator"; Can Min Metall Bull 74:827:200-207; 1981

This paper provides a description of the Highmont copper-molybdenum concentrator from primary crushing through grinding, flotation, tailings disposal and water reclamation. The unique features of the operation will be emphasized. (Author)

1703. Aytekin, Y. "Wet chemical extraction of metals from bulk concentrates of nonferrous ores"; Aufbereit Tech 22:2:62-71; 26 ref; 1981.

This investigation aims at finding ways to extract the metals from copper-lead-zinc bulk concentrates by wet chemical treatment. The part of the investigation - Fine grinding - deals with the alteration of the property characteristics under the influence of mechanical pre-treatment. In the part - Roasting and leaching - a combination of thermal pre-treatment and subsequent leaching is tested. Furthermore, tests on direct leaching after mechanical pretreatment are described. Results of the experiments are reported. (Author)

1704. Anon. "Coal beneficiation. 1976 - November, 1980 (Citations from the Engineering Index Data Base)"; U.S. NTIS Rep PB81 - 801 482: 328 pp.; December, 1980

1705. Ruzong, L. "Practice of beneficiation of clay-like eluvial talus tin ores"; Nonferrous Met (China) 32:4:29-32; (Chinese); 1980

1706. Karnaukhov, S.N.; Peskov, V.V.; Kornienko, Ya.P.; Ustimov, O.P. and Ur'ev, G.G. "Analysis of tin losses with muds in the pulverization of finely disseminated tin-containing ores"; Obogashch Rud(Leningrad) 25:4: 19-22; (Russian); 1980

1707. Saranchuk, V.I.; Rekun, V.V. and Pashchenko, L.V. "Changes in the properties of coals during preparation for crushing"; Khim Tverd Topl (Moscow) 1:99-104; (Russian); 1981

1708. Okunev, V.V.; Khmel'kovskii, I.E. and Romanov, G.P. "Criteria for the selective crushing of vein-disseminated copper-molybdenum ore"; Soversh Protsessov Rudopodgotovki L 121-123; (Russian); 1980

1709. Kursakov, G.M.; Tumanyan, V.A; Chekmarev, V.N.; Yashin, V.P. "Effect of the consumption of inoculants on the intensification of grinding and the subsequent beneficiation of copper-molybdenum ore"; Soversh Protsessov Rudopodgotovki L 108-115; (Russian); 1980

NOVEL METHODS

1710. Kawabata, Shigekatsu "Simultaneously subjecting ores to pulverization and leaching or extraction"; South African Patent 79 04273:10 pp.; September 24, 1980

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INTRODUCTION

This report presents bibliographical information on the subject of crushing and grinding. References were obtained through the CAN/SDI system covering the following data bases:

CHEMICAL ABSTRACTS (CA)	95:12-22; 1981
COMPENDEX	81:10-12; 1981
METADEX (Metal Abstracts)	81:10-12; 1981
NTIS (National Technical Information Service of the U.S. Dept of Commerce)	81:22-26; 1981
SCIENCE CITATION INDEX	81:34-46; 1981

The following abstract journals were also searched:

CURRENT AWARENESS IN PARTICLE TECHNOLOGY	14:10-12; 1981
IMM ABSTRACTS	31:5-6; 1981

References are numbered sequentially and are grouped according to the main topics shown below. Not all topics need to be presented in any one report.

A) Review articles
B) Crushing
C) Rod and ball mill grinding
D) Autogenous, semi-autogenous and pebble grinding
E) Liners and wear
F) Grinding media
G) Classification
H) Modelling, kinetics and process control
I) Fracture
J) Applications
K) Novel methods

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CRUSHING

1711. Butterworth, G.J. "Portable crushing plants: design trends and applications in the USA"; Quarry Manage Prod 8:7:485-492; 1981

1712. Harrison, J. "Mobile crushing plant in the UK: Current trends and prospects"; Quarry Manage Prod 8:7:495-499; 1981

1713. Benecke, K.J. "Crushers and conveyors versus trucks"; World Min 34:6:86-87; 1981

The use of fully mobile crushers directly fed by the face shovel is well established - Krupp has built more than 30 mobile units - whereas the partial elimination of truck haulage by semi-mobile in-pit crushers is a more recent development. This latter method restricts truck haulage to in-pit operation only, saving costly haulage of material up-grade out of the pit to the crusher or overburden dump. It is particularly applicable to operations where ore blending is required. In such cases, the flexibility and adaptability of trucks to frequently changing faces is essential, while the semi-mobile crusher reduces haul distances to a minimum.

The example in this paper deals with the application of semi-mobile in-pit crushers for ore and overburden in a theoretical mine. This is done by comparing the costs of truck transport alone with a combination of trucks, semi-mobile crushers, conveyors, and stackers. (Author)

1714. Venkatash, A. "Role of crushing and screening equipment today"; Ind Min Eng J 19:12:23-27; 1980

1715. Hamel, E. "Trends in the development of mobile and semi-mobile crushing plants"; TIZ Fachber 105:5: 317-319; (German); 1981

1716. Sieburg, S. and Kelleners, W. "Preclassifying with mobile screen units in mobile crushing plants"; Aufbereit Tech 22:7:362-366; 1981

1717. Revnivtsev, V.I. "Recent trends in the preparation of ores for beneficiation processes"; In: Mineral Processing 13th Int Miner Process Congr Part B; edited by J. Laskowski; June 4-9,1979; Warsaw; 1061-76; 1981

The importance of ore preparation (comminution, classification) results from the energy consumption in these operations (40-65% of the total power consumption in the concentrator) and from the necessity for proper liberation of ore mineral constituents which is a decisive factor in overall efficiency, especially in the case of low grade ores. The present view of size reduction processes, based mainly on classical mechanics, cannot be regarded as a reliable foundation for the development of selective liberation theory.

The process of rock breakage begins during mining operations and it is thus concluded that proper organization of a joint mining-preparation system should lead to further technological improvement and energy conservation. (Author)

1718. Sher, E.N. and Chernikov, A.G. "Shear method of uniform rock crushing during an explosion"; Sov Min Sci 16:6:518-521; 3 ref; 1980

When rock is crushed by an explosion the spoil consists of fragments of different sizes and shapes. However, in many cases a specific fraction is required. How can the scatter of the fragment size be reduced? The scatter is due to many causes. In our opinion, the two most important of these are as follows: 1) the nonuniformity of the strength properties on the solid rock; 2) the nonuniformity of the action of the explosion on this rock. As a consequence of the latter factor, at different points in the rock the mean fragment size, found from a small sample, differs: near the charges it is smaller, further away it is correspondingly larger.

In earlier papers we proposed a fundamental scheme of an explosion precluding the latter factor and ensuring the theoretically absolute uniformity of crushing over the solid rock.

This article gives a brief account of this scheme together with the results of a semi-industrial check. (Authors)

1719. Weinert, H.H. "Aggregate crushing value and the 10 per cent fines aggregate crushing test compared"; 7th Soil Mech Found Eng Proc Reg Conf Afr; June, 1980; Accra, Ghana; 1:191-200; 1980

ROD AND BALL MILL GRINDING

1720. Austin, L.G.; Shah, J.; Wang, J.; Gallagher, E. and Luckie, P.T. "An analysis of ball-and-race milling. Part I. The Hardgrove mill"; Powder Technol 29:2: 263-275; 10 ref; 1981

The basic principles of mill action were investigated in the batch Hardgrove ball-race machine, modified by the addition of a torque device. It was found that the torque to drive the mill after correction for bearing friction was almost proportional to load M on the balls and independent of rotational speed ω, so that the mill power was proportional to $M\omega$. The first-order specific rates of breakage were proportional to M and ω. Torque increased as the power in the race increased, then reached almost a constant value, as did the absolute rate of breakage. As fines accumulated in the charge breakage became non-first-order, showing a slowing-down effect for all sizes. An easy method of simulation of this condition was demonstrated. (Authors)

1721. Dombrowe, H. and Hecht, C. "Sound level measurements in ball mills"; Silikattechnik 32:4:110-111; (German); 1981

1722. Abouzeid, A. and Fuerstenau, D.W. "The performance of an industrial balling circuit"; Prepr Soc Min Eng Am Inst Min Metall Pet Eng 80-405: 13 pp.; 1980

1723. Gouda, G.R. "Technical aspects of comminution in the cement industry. Part I"; World Cem Technol 12:3: 112-122; 1981

1724. Gouda, G.R. "Technical aspects of comminution in the cement industry. Part II"; World Cem Technol 12:4: 156-169; 21 ref; 1981

1725. Yudovich, B.E.; Vlasova, M.T. and Kalyanova, V.N. "The origin of fine cement fractions in the ball mill"; In: XIII Conf on Silicate Ind and Silicate Sci; edited by M. Palocz; June 1-5; Budapest, Hungary; 104-110; (Russian); 1981

1726. Szucs, A. and Verdes, S. "Testing and evaluation methods to improve the effectivity of dry grinding, and their application in following the effect of grinding media in ball mills"; In: XIII Conf on Silicate Ind and Silicate Sci; edited by M. Palocz; June 1-5; Budapest, Hungary; 277-282; (Hungarian); 1981

1727. Schramm. K. "Optimum ball mill operation"; In: XIII Conf on Silicate Ind and Silicate Sci; edited by M. Palocz; June 1-5; Budapest, Hungary; 236-242; (German); 1981

1728. Molerus, O. and Paulsen, H. "Axial dispersion of the mill charge and energy efficiency in continuous milling in the ball mill"; Chem Ing Tech 42:5:18 pp.; 1970

AUTOGENOUS, SEMI-AUTOGENOUS AND PEBBLE GRINDING

1729. Shcherbakov, V.I.; Panchenko, A.F.; Vasyagin, A.I. and Zolotorev, A.P. "A self-grinding process for antimony ores"; Tsvetn Metall Nauchno-Tekh Sb 19: 1-15:17-20; (Russian); October, 1980

LINERS AND WEAR

1730. Moroz, P.J. and Lorenzetti, J.J. "The effects of matrix hardness and microstructure on the wear of steel grinding balls during wet copper ore grinding"; Wear of Materials; March 30-April 1, 1981; San Francisco, California; 280-289; 17 ref; 1981

1731. Catanante, Santo "Abrasion resistant steel composition"; Braz. Patent 78 02348:11 pp.; (Portuguese); November 27, 1979

1732. Heinrich, Wilm; Illgen, Lothar; Fiedler, Werner and Krumphold, Ralf "Highly wear-resistant parts for mixing and grinding equipment"; Ger. (East) Patent 146 150:4 pp.; (German); January 28, 1981

1733. Maryuta, A.N. and Kovalenko, A.N. "Control of the state of lifters and lining in drum mills by analysis of the characteristics of the driving motors"; Sov Non-Ferrous Met Res 8:1:91; 1980

GRINDING MEDIA

1734. MacMillan, N.H. and Dias, O.C. "Chemomechanical behavior of coal"; Trans Soc Min Eng Am Inst Min Metall Pet Eng 266:1886-92; 1979

1735. El-Shall, H.; Gorken, A. and Somasundaran, P. "Effect of chemical additives on wet grinding of iron-ore minerals"; In: Mineral Processing 13th Int Miner Process Congr Proc Part A; edited by J. Laskowski; June 4-9, 1979; Warsaw; 695-726; 10 ref; 1981

A study on the effect of both inorganic and organic additives on wet grinding of iron ore constituent minerals (quartz and hematite) has shown that improved grinding can be obtained but only under certain levels of the additive concentration and pH. Under other conditions, the chemical additions can produce even deleterious effects. These effects are compared with those normally obtained for flotation.

Zeta potential and flocculation characteristics of the systems determined under conditions similar to that of grinding tests have been used to elucidate the mechanisms involved. It was found that the effect of the chemical additives can often be masked by their ability to flocculate the ground products. Microscopic examination of the ground products (dispersed and sieved) has clearly shown the possibility for the existence of major experimental artifacts due to incomplete dispersion in the past work.

Also, the interaction of such additives with the performance of subsequent flotation is also examined here. (Authors)

1736. Buczek, Bronislaw; Czaplinski, Andrzej; Czepirski, Leszek and Holda, Stanislaw "Effect of the sorption of chemical compound vapors on the comminution of coal in a ball mill"; Przegl Gorn 37:2:78-80; (Polish); 1981

1737. Gustaw, Krystyna and Koszczynialski, Wojciech "Grinding of cement in Minipebs mills with addition of Flotanol as a surfactant"; Cem Wapno Gips 8-9: 226-30; (Polish); 1980

1738. Gurevich, B.I.; Dobrovskaya, N.M. and Ryabinina, E.M. "Si-stoff-An active mineral additive to a portland cement clinker during grinding"; Stroit I Tekhn Materialy Iz Mineral'n Syr'ya I Prom Otkhodov L 18-24: (Russian); 1980

CLASSIFICATION

1739. Merrill, F.H. "Program calculates hydrocyclone efficiency"; Chem Eng (NY) 88:22:71-78; 7 ref; 1981

The author provides an explanation of how the hydrocyclone works and its application to mineral processing. The efficiency of the separation in a hydrocyclone is defined in terms of the underflow for each size fraction within a grinding-separation circuit. Values for the efficiency can be graphed for each size fraction, producing the Tromp curve.

The author presents a calculator program for the Hewlett Packard Model HP-41C. With inputs for the specific gravity of the solid material, the solids content of the feed, overflow and underflow, the number of size fractions, and results from a screen analysis of the overflow and underflow solids, the calculator enables the user to draw the Tromp curve.

1740. Schraffl, G. "System output substantially increased by changing Flip-Flow sieve in an ore crushing/screening system"; Aufbereit Tech 22:7:372-373; 1981

1741. Schonert, K. "On producing required particle size distribution"; Inst Chem Eng Symp Ser 63; 1981

1742. Miller, Jan D. "Hydrocyclone for improving separation of solids"; U.S. Patent Appl. 94521, November 15, 1979; European Patent Appl. 29 553, June 3, 1981

1743. Gerdt, R.A.; Pudnikov, A.P. and Rubtsov, N.V. "Ore preparation in heavy suspensions"; Tsvetn Metall Nauchno-Tekh Sb 17:1-15:42-44; (Russian); September, 1980

1744. Tishchenko, E.I. "Dependence of the flatness of placer gold particles on their screen sizes"; Dokl Akad Nauk SSSR 259:6:1436-1439; 8 ref; (Russian); 1981

1745. Stanleywood, N.G.; Llewellyn, G.J. and Taylor, A. "On-stream particle-size, concentration, and velocity measurements by auto-correlation of scattered laser light"; Powder Technol 29:2:217-223; 6 ref; 1981

With the increase in automatic control of powder processes there is now a need for on-stream or real time instrumentation to measure the size and solid concentration of particles in slurries.

On-stream velocity, particle size and concentration have been obtained by the interrogation of sand-water slurries by two 5 mW HeNe laser beams. The scattered laser light, from concentrated slurries in the range 1.0×10^{-4} - 1.0% w/w flowing at velocities between 0.5 - 3.0 m/sec in a 2.5 cm diameter vertical pipe, is transduced by a photodetector into random fluctuating electrical signals. The individual signals are auto-correlated and the power spectra computed to determine the particle size range and concentration of the suspended particles while the velocity of flow is determined from cross-correlation of the signals obtained from the axially separated lasers.

The change in particle concentration and size jointly affect the shape of both the auto-correlogram and the power spectral density of the photodiode signal. By improved methods of detection, instrumentation implementation and data analysis, the velocity, particle size and concentration in a flowing suspension can be separately evaluated. (Authors)

1746. Beddow, John Keith "Dry separation techniques"; Chem Eng (NY) 88:16:70-84; 31 ref; August 10, 1981

1747. Austin, L.G. and Klimpel, R.R. "An improved method for analyzing classifier data"; Powder Technol 29:2: 277-281; 8 ref; 1981

A common problem in calculating classifier selectivity values occurs when experimentally measured size distributions of the three streams around the classifier do not extend to small enough sizes to obtain a direct value for the bypass fraction. For hydrocyclones, it is sometimes assumed that the bypass fraction equals the water split, but this is not in agreement with test results reported here. A mathematical procedure is outlined for obtaining the complete selectivity curve based on extrapolation of the smaller sizes of the feed size distribution on a Schuhmann plot, and fitting the selectivity curve to a three parameter function (bypass, d_{50} and steepness parameters). This procedure uses the information contained in the percentages less than the smallest measured size, whereas the normal calculation technique wastes this information. An example is given of the new procedure applied to hydrocyclone data.(Authors)

1748. Taushkanov, G.P. "Generalized formula for calculating the collection efficiency of geometrically similar cyclones"; J Appl Chem USSR 53:11:1823-1826; 4 ref; 1980

With the assumption of dependence of the fractional escape factor on the Stokes number at a constant ratio of the volumetric flow rates in the outlet pipe and the cyclone, correlations in the field of the theory of similarity of mass-transfer processes in cyclones for polydisperse dust whose particle-size composition conforms to the Gaudin-Andreev formula were reported earlier. Simple formulas for determination of escape factors in geometrically similar cyclones were obtained.

In the present communication this solution is extended to the case where the fractional escape factor is a function of the Stokes, Reynolds, and Froude similarity criteria. The problem is solved with exactly the same assumptions as before. (Author)

1749. Kelsey, G.D. "Dry classification processes related to mill systems"; Filtr Sep 18:3:218-20; 1981

The identification of the correct type of classifier to be incorporated in a grinding circuit is fundamental to the total grinding process. There is a limit to which screens can be included, but this does not give total exclusion to their use. However, classifiers can be readily installed into total comminution circuits to give resultant superfine products. If ultra fine products are required then some consideration will need to be applied to the use of fluid energy mills, which in general, by virtue of their grinding action give a product of the desired particle size. (Author)

MODELLING, KINETICS AND PROCESS CONTROL

1750. Morozov, E.F. "Kinetic equations for grinding in drum mills"; Sov Non-Ferrous Met Res 8:1:1-6; 8 ref; 1980

1751. Wellstead, P.E.; Munro, N. and Cross, M. "Modelling, stability and control of an iron ore balling drum circuit"; Trans Inst Meas Control 2:2:86-99; 1980

1752. Opoczky, L. and Mrakovics, T.K. "Description of grinding process based on the n-diagram of a mill"; Silikattechnik 32:4:104-106; (German); 1981

1753. Steinert, H.E. "Level measurement and prevention of overfilling in the coal grinding plant of the Lagerdorf cement works"; Zem Kalk Gips 34:9:468-70; (German); 1981

The use of level monitoring devices and safeguards against overfilling are described, with particular reference to the choice of the monitoring points rather than to the function of the equipment employed (microwaves, ultrasonic measurement, gamma rays). (Author)

1754. Brayshaw, M.D. "Sharpening of the hydrocyclone efficiency curve by modification of the vorticity function of the flow field by use of a numerical model"; Proc 3rd Natl Meet, S Afr Inst Chem Eng; April 1-3; Univ of Stellenbosch, S. Afr.; 1-38; 4 ref; 1980

1755. Tverskoi, Yu. S.; Ballod, B.A. and Kukushkina, I.V. "Investigation of statistical characteristics of active capacity signal of hammer mill motors"; Teploenergetika 2:43-48; (Russian); February, 1981

1756. Arsent'ev, V.A.; Borisov, B.M.; Pereselkov, N.N. and Posypkin, L.D. "Control of grinding-flotation dressing of detalced ores"; U.S.S.R. Patent 831 181; (Russian); May 23, 1981

1757. Smirnov, N.M.; Blinichev, V.N. and Strel'tsov, V.V. "Calculation of the particle size composition of a material ground in impact-reverberatory mills"; Teor Osn Khim Tekhnol 15:3:424-8; (Russian); 1981

1758. Schonert, K. "Mathematical simulation of comminution processes. Part I. The general model and the stationary special case"; Chem Ing Tech 43:6:16 pp.; 1971

1759. Gallyas, M.; Hilger, M. and Juhasz, I. "Energy-saving operation of closed-circuit cement mills by the measurement of residence time"; In: XIII Conf on Silicate Ind and Silicate Sci; edited by M. Palocz; June 1-5; Budapest, Hungary; 25-31; (Hungarian); 1981

1760. Fogolyan, J.; Mikoczy, K.; Mikecz, M. and Fekete, L. "Automatization of the crushing and sorting equipment in a quarry using a programmable logic-controller"; In: XIII Conf on Silicate Ind and Silicate Sci; edited by M. Palocz; June 1-5; Budapest, Hungary; 211-216; (Hungarian); 1981

1761. Krivenko. P.V.; Skurchinskaya, Z.V. and Chirkova, V.V. "Physical-chemical bases of increasing the efficiency of grinding systems"; In: XIII Conf on Silicate Ind and Silicate Sci; edited by M. Palocz; June 1-5; Budapest, Hungary; 132-138; (Russian); 1981

1762. Mehrim, M.R. and Khalaf, F. "Kinetics of comminution in slow compression tests"; Proc 21st Symp Rock Mech, Rock Mech: A State of the Art; May 28-30; Univ of Mo, Rolla; 410-418; 18 ref; 1980

APPLICATIONS

1763. Tilyard, P.A. "Recent developments in grinding and flotation at Bougainville Copper, Ltd., Papua New Guinea"; Inst Min Metall Trans Sect C 90:C89-95; September, 1981

Updated information is given on the Bougainville Copper grinding and flotation sections. There has been a continuing emphasis on the improvement of grinding circuit efficiency, in terms of throughput/grind and mechanical availability and utilization. This has been achieved by further mill speed-up, liner development, improved cyclone operation, improved service water supply and extension of the mill service interval. Other operating refinements are described.

The major flotation circuit development has been the installation of a Courier 300 on-stream analysis system. The basis for the selection of this equipment and the problems that were encountered are discussed.

Plans for the improvement of Davcra cell operation, investigation of by-product recovery, the trial of large flotation mechanisms and the current operating philosophy are also discussed. (Author)

1764. Kortmann, F.H. and Ansen, J. "Inert combined grinding and drying of solid fuels at the Rheinischen Braunkohlenwerken"; Zem Kalk Gips 34:9:458-467; (German); 1981

The increasing consumption of coal dust for the most diverse applications requires, nowadays and in the near future, technological solutions for the production of pulverous fuel, which make reliable large production units possible. The Rheinische Braunkohlenwerken are erecting a combined grinding and drying plant where apart from briquettes broken parts and fines also pit coal can be ground. The

selected plant concept of a full-time inert combined grinding and drying plant the supply of which has been awarded to KHD Humboldt Wedag AG is explained and described in the following. (Authors)

1765. Westergard, A.F. "Bucim copper project: Yugoslavia's new $85 million mine and flotation concentrator will produce 100,000 mt/yr of copper concentrate"; Eng Min J 182:5:76-83; May, 1981

1766. Abramov, V.Ya.; Narushevich, L.P.; Sizyakov, V.M. and Melts, M.S. "Grinding and leaching of Gibbsite"; Tsvetn Metall Nauchno-Tekh Sb 4:21-22; (Russian); February, 1981

1767. Markotic, A. "Scientific research in the preparation of iron ores"; Celik (Belgrade) 17:88:19-22; February, 1981

NOVEL METHODS

1768. Miller, R.N. and McLane, D.M. "Koppers tower mill - A new approach to size-reduction"; Am Ceram Soc Bull 60:3:349; 1981

1769. Grizina, K.; Meiler, H. and Rosenstock, F. "Centrifugal mill- a new grinding machine for ores and mineral raw materials"; Aufbereit Tech 22:6:303-308; 2 ref; 1981

POOR

QUALITY

ORIGINAL